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A GROUND TRUTH ANALYSIS OF DMSP WATER VAPOR RADIANCES.(U)
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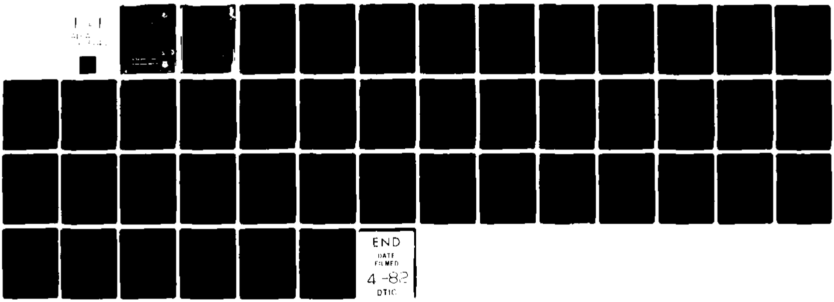

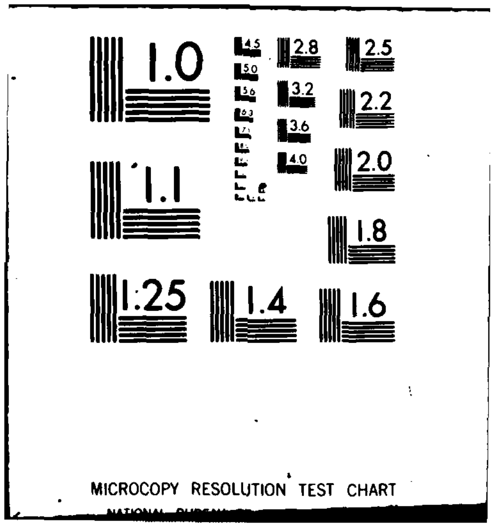
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SSH H_2O data from the Defense Meteorological ... Program (DMSP) were received for analysis and evaluation. Approximately 70 measurements of upwelling radiation in the 8-sounder channels of the 18 to 30 μm rotational water vapor band have been compared with calculations for both clear and cloud contaminated conditions. The calculated radiances generally exceed the measured radiances in the clear column comparison. In the mean, the radiance comparison indicates a discrepancy less than 5 percent in the water vapor continuum band. This systematic discrepancy, by approximately a

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4:1 ratio, is found in all the DMSP SSH H_2O channels. These results are in agreement with McClatchey's 1976 results in his analysis of the DMSP 15 μm CO_2 sounder channels.

The data sets comparison were divided into three latitude belts, that is, Tropical, Mid-latitude and Arctic. In turn, the discrepancies between calculated and measured radiances appear to be latitudinally dependent. Smaller discrepancies are found in the Tropics and the larger discrepancies are found in the Arctic latitude belt. Also, it appears that the DMSP SSH H_2O channels cannot discriminate between low cloud contamination and clear column conditions.

Preface

The author wishes to acknowledge the following organizations and individuals: the Air Force Global Weather Center for supplying the DMSP HPKG data; the USAF Environmental Technical Applications Center for supplying the ground truth data; Dr. Robert McClatchey for use of his computer programs; Dr. Jean I. F. King for reviewing the manuscript; Ed Lefebvre for his programming skills and Celeste Gannon for her typing the manuscript.

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1. INTRODUCTION

The Defense Meteorological Satellite Program (DMSP) Block 5D Satellite carries a Special Meteorological Sensor H (SSH) package. An excellent review of the optical subsystems and the spectral characteristics of this SSH package is provided by Nichols.[1] Infrared energy is measured in 16 spectral bands by the SSH package: six spectral channels are located in the 15 μm carbon dioxide bands, eight in the 18 to 30 μm rotational water vapor band, one in the 9.6 μm ozone band, and one in the atmospheric window near 12 μm. In this study, the emphasis is placed on the eight DMSP water vapor SSH channels. The various channel characteristics are listed in Table 1.

Originally, the purpose of this study was: (1) to evaluate the DMSP multichannel water vapor radiances for informational content, and (2) to recommend some operational techniques whereby moisture parameters may be derived directly from DMSP water vapor radiance measurements. A preliminary evaluation of the DMSP water vapor radiances was made in a previous report[2] concerning the

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(Received for publication 2 November 1981)

1. Nichols, D. A. (1975) DMSP Block 5D special meteorological sensor H, optical subsystem, Opt. Eng. 14:284-288.
2. Valovcin, F. R. (1980) DMSP Water Vapor Radiances—A Preliminary Evaluation, AFGL-TR-80-0312, AD A099305.

informational content. Before a reliable operational technique on deriving moisture parameters could be recommended, the Forward Problem had to be investigated. By definition, the Forward Problem is the matching of satellite observed or measured and the classically-calculated radiances based on coincident in time and space radiosonde data. McClatchey[3] in studying the Forward Problem reported a systematic discrepancy, that is, calculations, in general, exceed the measured or observed radiances in the DMSP 15 μm carbon dioxide bands. As this study progressed, it became quite apparent that the purpose would change from recommending some operational techniques on deriving moisture parameters to conducting a Ground Truth Analysis of the DMSP water vapor radiances similar to McClatchey's study of the DMSP 15 μm carbon dioxide band. Thus in this report, a comparison program was carried out for approximately 70 sets of DMSP SSH water vapor measurements with calculated water vapor radiances. Both clear and cloud contaminated columns as a function of three latitude belts, that is, Tropical, Midlatitude and Arctic were used in this study. The DMSP water vapor radiance sets analyzed were from Flight II SSH aboard spacecraft WX 13536 and on a few occasions from Flight III SSH aboard spacecraft WX 14537. Flight II SSH and Flight III SSH were launched in July 1977 and April 1978 respectively.

Table 1. DMSP Water Vapor SSH Channel Characteristics*

Band	Center μm	Center cm^{-1}	Width cm^{-1}	NESR**
F1	28.2	355.0	15.0	0.25
F2	25.2	397.5	10.0	0.16
F3	23.8	420.0	20.0	0.12
F4	22.7	441.5	18.0	0.09
F5	18.7	535.0	16.0	0.15
F6	24.5	408.5	12.0	0.14
F7	26.7	374.0	12.0	0.18
F8	28.3	353.5	12.0	0.33

*After Nichols[1]

**NESR: Noise Equivalent Spectral Radiance in $mW/m^2\ sr\ cm^{-1}$

3. McClatchey, R.A. (1976) Satellite Temperature Sounding of the Atmosphere: Ground Truth Analysis, AFGL-TR-76-0279, AD A038236.

2. DMSP WATER VAPOR RADIANCE DATA

The Air Force Global Weather Central (AFGWC) forwarded to the Air Force Geophysics Laboratory (AFGL) printouts of world-wide SSH spectral radiance data for the period 00Z 30 January 1979 to 12Z 18 October 1979. The printouts contained information on date-time, latitude and longitude of the scan spot, Zenith angle, 3D NEPH[4] and data base parameters along with the spectral radiance measurements for the 16 DMSP spectral channels. The scan spot is the first cloud-free radiance set available within a 3° × 3° area as selected by AFGWC's HPKG software (based on the 3D NEPH files). Only the eight water vapor channels and the one located in the atmospheric window near 12 μm were used in this study.

The DMSP SSH sounder scan pattern is accomplished in 25 4-degree incremental steps from -48° to +48° of nadir across the orbit track. The range of zenith angles for the 25 scan spots are +57° to -57°. Zenith angles are designated positive on the left and negative on the right of the scan swath. At nadir the scan spot on the earth's surface is approximately 21 nmi (39 km) and increase to approximately 35 by 25 nmi (65 × 46 km) at a zenith angle of +/-32°. The analysis was limited to zenith angles of +/-32° or approximately +/-245 nmi (454 km) from nadir.

3. GROUND TRUTH DATA

The USAF Environmental Technical Application Center (ETAC) provided the ground truth data for the various stations world-wide. A "ground truth" site is defined as a radiosonde observation being within +/-3 hrs and 100 nmi (185 km) of a DMSP satellite scan spot. Atmospheric conditions such as clear or cloud contaminated were determined through surface observations, AFGWC three-dimensional nephanalysis (3D NEPH) and the radiosonde observations. Imagery was not generally used because of the period involved (January-October 1979) and the final selection of the "ground truth" site world-wide. The radiosonde data were received in a LOWTRAN format with the following parameters: Height (km), Pressure (mb), Temperature (°C), Dewpoint Temperature (°C), Relative Humidity (%), and Absolute Humidity (g/m^3). The values of absolute or relative humidity above 300 mb are climatologically modeled by ETAC since the radiosonde usually does not report humidity above this level. An example of the detailed atmospheric profile of temperature, water vapor, and ozone as a function of height and pressure that is used in the transmittance calculations is shown in Table 2. The concentration

4. Coburn, A. R. (1970) Three Dimensional Analysis, AFGWC, Offut AFB, NE, AFGWC TM-70-9.

of water vapor was calculated as described by Selby and McClatchey.[5] The ozone data were introduced from climatological models of ozone distributions. The units of water vapor and ozone are in molecules/cm^2 and are integrated values from the top of the atmosphere to the surface.

Table 2. Atmospheric Profile and Composition Derived From Radiosonde Data—West Palm Beach, Florida, 72203-790403

HT (km)	Pressure (mb)	Temp (K)	Water Vapor (Molecules/cm^2)	Ozone (Molecules/cm^2)
31.3	10.0	237.9	1.067E+19	3.451E+16
29.2	13.5	232.5	1.155E+20	6.160E+17
28.7	14.5	235.3	1.372E+20	8.015E+17
26.6	20.0	228.1	2.106E+20	1.815E+18
25.6	23.0	223.1	2.230E+20	2.259E+18
23.9	30.0	221.7	2.377E+20	3.117E+18
20.7	50.0	211.9	2.496E+20	4.764E+18
19.4	62.0	200.3	2.517E+20	5.439E+18
18.7	70.0	200.9	2.529E+20	5.819E+18
17.8	81.0	200.3	2.544E+20	6.287E+18
17.7	82.0	198.1	2.545E+20	6.327E+18
16.9	95.0	203.9	2.561E+20	6.788E+18
16.6	100.0	201.9	2.569E+20	6.947E+18
16.4	102.0	201.3	2.571E+20	7.008E+18
14.6	138.0	202.3	2.661E+20	7.859E+18
14.1	150.0	203.9	2.625E+20	8.099E+18
13.6	165.0	205.9	2.646E+20	8.329E+18
12.4	200.0	215.7	2.764E+20	8.957E+18
10.9	250.0	227.9	3.396E+20	9.639E+18
10.2	278.0	236.3	4.905E+20	9.968E+18
9.7	300.0	237.9	6.983E+20	1.020E+19
7.6	400.0	254.7	1.266E+21	1.110E+19
5.9	500.0	266.3	1.949E+21	1.282E+19
4.7	581.0	275.6	3.294E+21	1.231E+19
3.2	760.0	284.0	6.999E+21	1.291E+19
2.2	791.0	289.6	1.125E+22	1.330E+19
1.9	811.0	289.6	1.233E+22	1.338E+19
1.9	819.0	283.0	1.336E+22	1.341E+19
1.5	850.0	285.8	2.164E+22	1.352E+19
1.3	876.0	287.0	2.877E+22	1.360E+19
0.7	944.0	290.4	5.222E+22	1.379E+19
0.2	1000.0	295.2	7.703E+22	1.393E+19
0.0	1018.0	295.4	8.475E+22	1.396E+19

These are integrated values

5. Selby, J.E.A., and McClatchey, R.A. (1975) Atmospheric Transmittance From 0.25 to 28.5 μm: Computer Code LOWTRAN 3, AFCRL-TR-75-0255, AD A017734.

4. ATMOSPHERIC WATER VAPOR TRANSMITTANCE

Atmospheric transmittance calculations for the DMSP SSH water vapor channels for the approximately 70 selected cases were computed using the McClatchey transmittance program developed at AFGL. In this program, line by line calculations are performed using the following equations from McClatchey.[3]

$$I_{\Delta\nu} = \left[\int_{\Delta\nu} f(\nu) \int_{\tau g}^{1.0} B(\nu, T)\, d\tau\, d\nu + \int_{\Delta\nu} f(\nu) B(\nu, T_S)\, d\nu \right] \Big/ \int_{\Delta\nu} f(\nu)\, d\nu \qquad (1)$$

which is the solution of the radiative transfer equation, where

$I_{\Delta\nu}$	is the radiant intensity in $mW/m^2\ sr\ cm^{-1}$,
$B(\nu, T)$	is the Planck blackbody function,
T	is the atmospheric temperature and T_s is the surface temperature,
τ	is the transmittance of the atmosphere from the altitude associated with the pressure level, p, to the top of the atmosphere,
ν	is the frequency (given here in cm^{-1}), and
$f(\nu)$	is the DMSP SSH instrument filter function.

McClatchey assumes that $B(\nu, T)$ is relatively constant over the width of a filter function (10 or 20 cm^{-1} wide), and he writes $\ell\eta\,(p)$ as an independent variable instead of τ, and obtains Eq. (2), where the quantity, $d\bar{\tau}/d\ell\eta\, p$, now becomes a weighting function that can be interpreted as defining the atmospheric layer primarily responsible for the upwelling emission in the spectral interval, $\Delta\nu$.

$$I_{\Delta\nu} \approx \int_{p_g}^{0} B(\bar{\nu}, \tau) \frac{d\bar{\tau}}{d(\ell\eta\, p)}\, d\ell\eta\, p + B(\bar{\nu}, T_s), \qquad (2)$$

$$\bar{\tau}_{\Delta} = \frac{f(\nu)\, \tau\,(\nu)\, d\nu}{f(\nu)\, d\nu}. \qquad (3)$$

Monochromatic transmittances were computed over the various eight DMSP water vapor filter functions for the appropriate radiosonde observation taking temperature, water vapor and ozone distributions as a function of pressure and height as shown in Table 2. These monochromatic transmittances were then weighted by the appropriate filter function as indicated in Eq. (3) in order to generate the appropriate averaged transmittance. The AFCRL Atmospheric Absorption Line Parameters Compilation[6] was used for all water vapor absorption lines between

6. McClatchey, R.A., Benedict, W.S., Clough, S.A., Burch, D.E., Calfee, R.F., Fox, K., Rothman, L.S., and Garing, J.S. (1973) AFCRL Atmospheric Absorption Line Parameters Compilation, AFCRL-TR-73-0096, AD A762904.

320-600 cm^{-1}. The calculation was based on the April 1979 data tape. The Lorentz line shape was used throughout with a line-wing modification of the water continuum proposed by Burch and Gryvnak.[7] The simple Lorentz line shape is used for $|\nu - \nu o| \leq 20\ cm^{-1}$ and varies linearly from unity at $|\nu - \nu o| = 20\ cm^{-1}$ to zero at $|\nu - \nu o| = 30\ cm^{-1}$. Also from this same report by Burch and Gryvnak,[7] the appropriate values of the temperature coefficient for the water vapor continuum were used and are listed in Table 3.

Table 3. Temperature Coefficient for Empirical Water Vapor Continuum*

ν (cm^{-1})	b (K)	ν (cm^{-1})	b (K)
320.	1197		
330.	1206		
340.	1214		
350.	1223	600.	1442
360.	1231	610.	1454
370.	1240	620.	1467
380.	1248	630.	1481
390.	1257	640.	1495
400.	1265	650.	1510
410.	1273	660.	1525
420.	1282	670.	1542
430.	1290	680.	1560
440.	1299	690.	1579
450.	1307	700.	1597
460.	1316	710.	1615
470.	1324	720.	1633
480.	1333	730.	1652
490.	1341	740.	1670
500.	1349	750.	1688
510.	1358	760.	1706
520.	1366	770.	1725
530.	1375	780.	1743
540.	1383	790.	1761
550.	1392	800.	1779
560.	1400	810.	1798
570.	1409	820.	1816
580.	1419		
590.	1430		

$$a_{C_s^\circ}(\theta) = a_{C_s^\circ}(296\,K)\exp\left(\frac{b}{\theta} - \frac{b}{296}\right)$$

*After Burch and Gryvnak

7. Burch, D. E., and Gryvnak, D. A. (1979) Method of Calculating H_2O Transmittance Between 333 and 633 cm^{-1}), Final Report AFGL-TR-79-0054, Aeronutronic Report U6503, AD A072850.

5. DMSP WATER VAPOR FILTER FUNCTIONS

In Appendix A, filter transmission curves and the digitized filter functions for the eight DMSP water vapor channels are provided. These curves and filter functions are valid for the Flight II SSH package aboard spacecraft WX 13536 launched in July 1977. The listed frequencies for each channel are normally the central frequency for each filter. The frequency steps for each channel were 0.5 cm^{-1}. These curves were used to calculate the water vapor transmittances and the resulting weighting functions according to Eqs. (2) and (3).

6. COMPARISONS BETWEEN DMSP WATER VAPOR MEASUREMENTS AND CALCULATED RADIANCES

The DMSP water vapor measurements were provided by AFGWC from their HPKG*RADISAVE HPKG files for the period February to October 1979. The radiances set of DMSP SSH data is the first cloud-free set available within a 3° X 3° area as selected by AFGWC's HPKG software (based on 3D NEPH files). As described in an earlier report,[2] this file also contained cloud contaminated scan spots. The radiosonde observation which was used as the "ground truth" site was obtained from ETAC in a LOWTRAN format. The transmittance calculations were based on the temperature and humidity profiles as a function of pressure from these radiosonde observations. The major criteria used in the colocated DMSP water vapor data and the "ground truth" site were as follows: (1) radiosonde station located within 100 nmi (185 km) of a DMSP scan spot, (2) radiosonde observations taken within +/-3 hr, and (3) zenith angle of the scan spot restricted to +/-32°.

The comparison between the DMSP water vapor measurements and the calculated radiances were divided into three latitude belts; that is, Tropical (26°S-26°N), Mid-latitude (26°-62°N) and Arctic (62°-90°N). In addition, the ground truth analysis considered both the clear and cloud contaminated scan spots. For illustration purposes, Figures 1, 2, and 3 depict the theoretical weighting function curves for the eight DMSP water vapor channels for a Tropical, Standard and Sub-arctic atmosphere respectively. The pressure, temperature and water vapor concentration for these three models are thosed used by McClatchey at al.[8] On the left side of these figures, the most opaque water vapor channels (F8-353,

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8. McClatchey, R.A., Fenn, R.W., Selby, J.E.A., Voltz, F.E., and Garing, J.S. (1972) Optical Properties of the Atmosphere (Third Edition), AFCRL-72-0497, AD A753075.

F1-355, F7-374 and F2-397 cm^{-1}) are shown. The less opaque or more transparent water vapor channels (F3-420, F4-441, F6-408, and F5-535 cm^{-1}) are shown on the right. The most opaque DMSP water vapor channel is F8-353 cm^{-1} and the most transparent is F5-535 cm^{-1}. The maximum value of the weighting function for each channel represents the approximate location in the atmosphere from which the major portion of the energy is received at the satellite sensor. Table 4 lists the location in mb of the maximum value of the weighting function for the three model atmospheres.

6.1 Clear Column Water Vapor Radiance Comparison

The colocated cases selected for comparison purposes designated clear are listed in Tables 5, 6, and 7 for Tropical, Mid-latitude, and Arctic latitude belts respectively. The 40 clear cases—Tropical (10), Mid-latitude (21), and Arctic (9) were selected based on surface reports, 3D NEPH and the radiosonde humidity profile. The tables list the stations, location, date, zenith angle, distance between the satellite scan spot and the radiosonde or "ground truth" station along with the satellite measured and the calculated water vapor radiances in mW/m^2 sr cm^{-1} for the eight DMSP water vapor channels. The calculated radiances were computed from Eqs. (2) and (3) using the radiosonde of temperature and humidity observations coincident in space and time as "ground truth".

Figures 4, 5, and 6 show the results of the comparison in graphical form. As can be seen from both the tables and the figures, the calculated water vapor radiances are greater than those measured by the satellite in the majority of cases. The percentage deviations in the mean are listed in the tables and are defined as (measured - calculated) ÷ measured radiance in percent. A positive (negative) deviation indicates that the measured is greater (less) than the calculated radiance. In the mean, the smallest percentage deviations are found in the Tropics and the largest in the Arctic latitude belt. The range of mean percentage deviations for the eight DMSP channels are +0.2 percent to -4.5 percent for the three latitude belts in the clear column comparisons. The ratio of negative to positive percentage deviations for the various latitude belts are: Tropic 52:28, Mid-latitude 132:36, and Arctic 70:2 for a total of 253 negative vs 67 positive percentage deviations. Thus, the calculated as indicated by the negative deviation exceed the satellite measured water vapor radiances by almost a 4:1 ratio. In addition, the calculated exceed the measured water vapor radiances in excess of +/-2.0 mW/m^2 sr cm^{-1} by almost a 3:1 ratio. The correlation between measured and calculated water vapor radiances are higher for the most transparent channels, that is, F5-535 and F6-408 cm^{-1} and lower for the most opaque water vapor channels, that is, F8-353 and F1-355 cm^{-1}. The lower correlations for the most opaque channels may be due to the use of the climatological humidity values above 300 mb. Also, it should be noted the maximum percentage deviations for all three latitude belts are found in the DMSP water vapor channel F3-420 cm^{-1}.

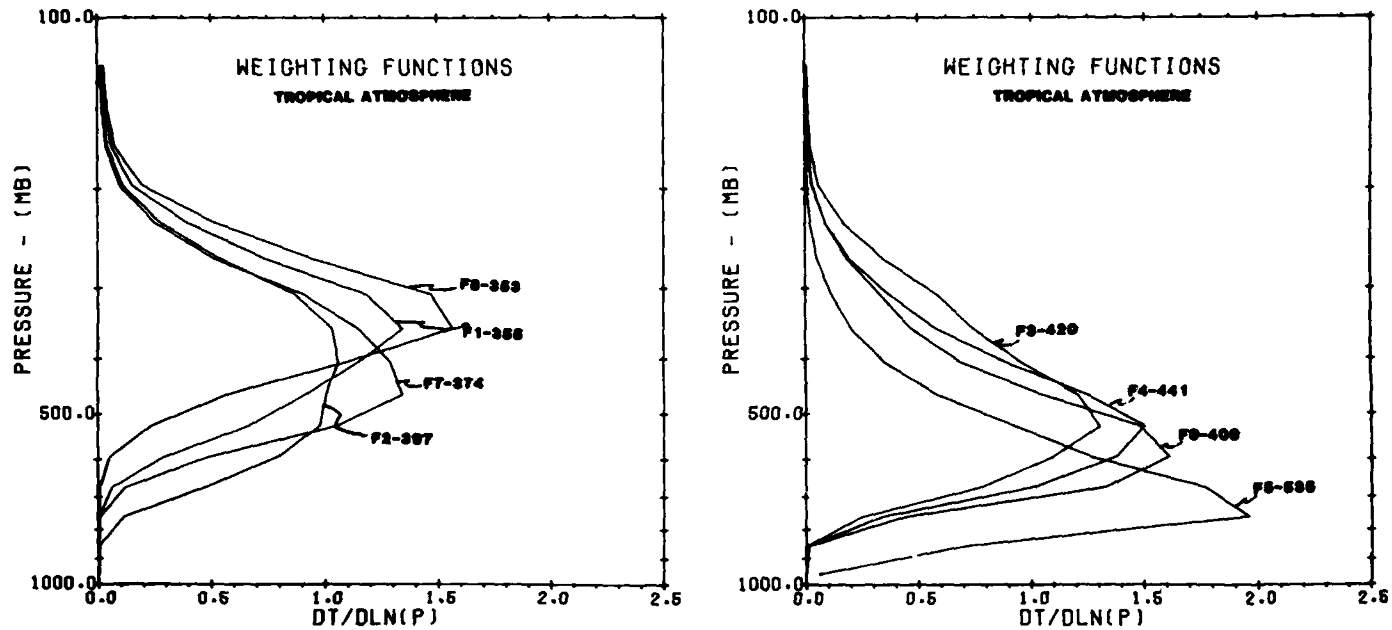

Figure 1. Weighting Functions for the DMSP SSH H_2O Channels—Tropical Atmosphere

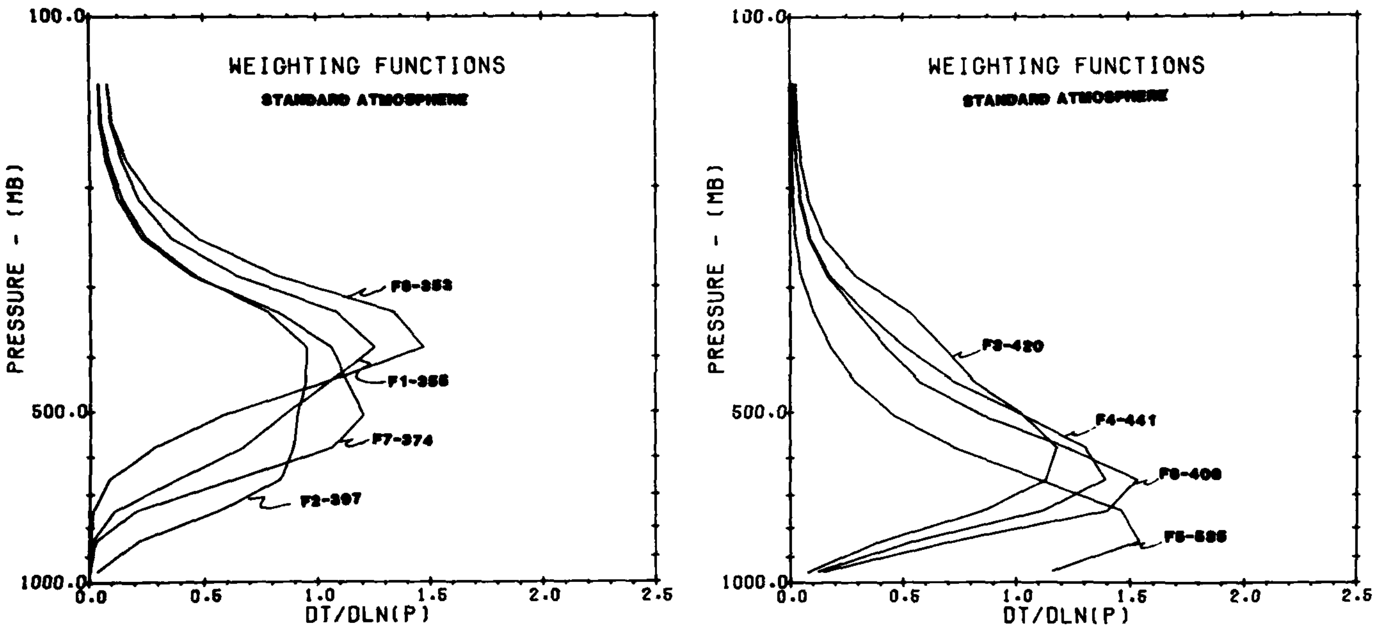

Figure 2. Weighting Functions for the DMSP SSH H_2O Channels—Standard Atmosphere

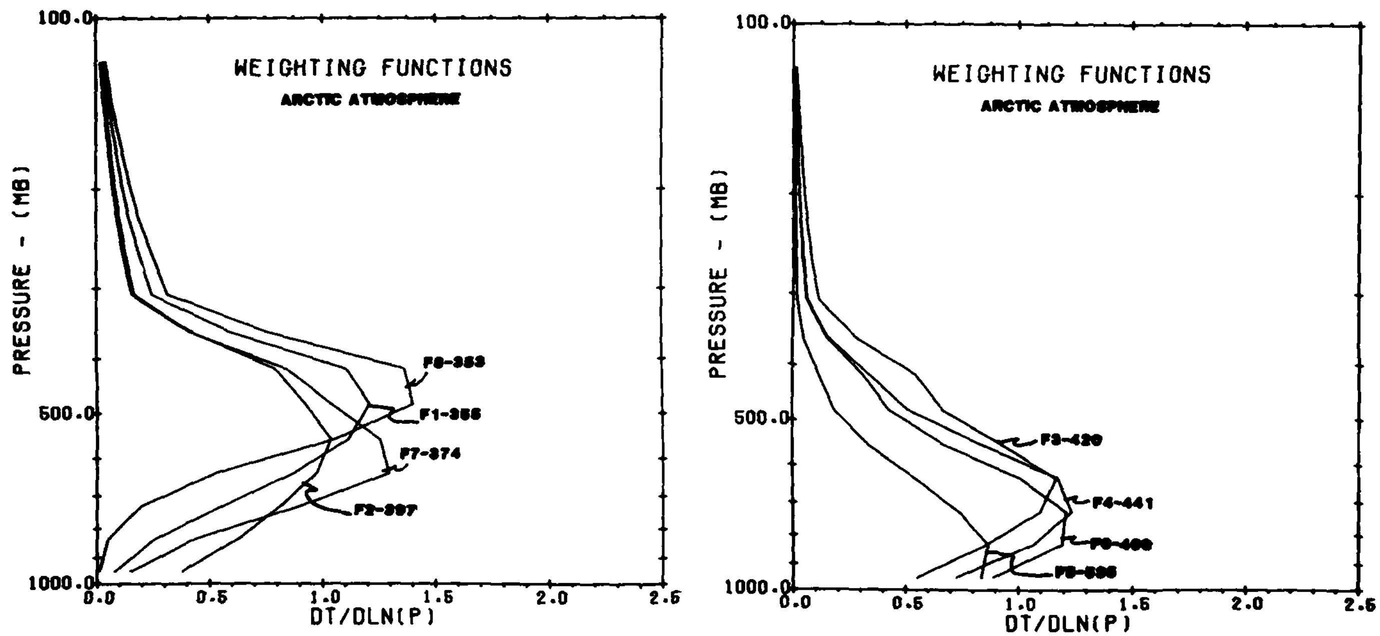

Figure 3. Weighting Functions for the DMSP SSH H_2O Channels—Arctic Atmosphere

Table 4. Location of the Maximum Value of the Weighting Function for the DMSP Water Vapor Channels

DMSP Channel	Tropical (mb)	Standard (mb)	Arctic (mb)
F1-355 cm^{-1}	355	385	480
F2-397	405	580	555
F3-420	525	580	635
F4-441	525	660	730
F5-535	760	845	835
F6-408	595	660	835
F7-374	460	505	635
F8-535	355	385	480

Table 5. Comparison of Measured With Calculated Radiances—Tropical (26S-26N)—Clear

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353
Measured	Jiddah, SA	790406	22.74	99 nmi	79.0	92.9	100.0	107.5	130.1	105.6	86.6	74.8
Calculated	21.5N 39.2E				81.5	94.5	104.9	110.6	129.2	108.0	90.5	77.9
Measured	Jiddah, SA	790406	18.16	66 nmi	79.0	92.4	100.0	107.6	129.4	105.6	86.5	74.5
Calculated	21.5N 39.2E				81.7	94.7	105.1	110.8	129.4	108.2	90.6	78.1
Measured	Chiang Mai, TH	790409	18.16	90 nmi	75.1	88.3	94.6	101.8	120.1	100.6	82.3	71.4
Calculated	18.78N 98.98E				75.7	87.4	96.6	102.0	119.7	100.5	83.1	72.7
Measured	Ascension Island	790329	9.05	99 nmi	82.7	94.3	102.0	108.4	124.4	105.5	89.1	78.6
Calculated	7.97S 14.4W				77.4	89.8	99.6	105.0	123.1	103.5	85.4	74.2
Measured	Ascension Island	790507	22.8	77 nmi	82.1	94.6	100.9	107.7	122.1	105.0	89.1	82.8
Calculated	7.97S 14.4W				80.9	92.8	101.7	106.6	121.9	104.3	88.8	77.8
Measured	Coolidge Field, AT	790202	-9.05	52 nmi	84.7	95.4	103.8	110.9	126.7	107.6	92.2	79.6
Calculated	17.12N 61.78W				81.2	93.0	101.1	107.0	126.1	105.8	88.1	77.2
Measured	TRUK KA	790603	-18.04	31 nmi	76.0	88.5	94.5	101.3	119.1	99.3	82.9	73.5
Calculated	7.47N 151.8E				76.7	89.1	98.6	104.1	125.0	103.2	84.1	73.7
Measured	MT ISA MO AU	790328	-22.86	92 nmi	75.0	89.5	96.2	104.2	127.4	103.0	82.4	70.3
Calculated	20.67S 139.48E				78.5	90.5	100.1	105.3	124.2	103.4	86.5	75.4
Measured	MT ISA MO AU	790330	32.2	32 nmi	76.3	88.5	94.6	101.2	119.2	99.5	82.8	72.0
Calculated	20.67S 139.48E				76.9	88.6	97.7	102.8	120.1	101.2	84.4	74.0
Measured	Giles MO AU	790401	4.52	91 nmi	73.0	84.3	90.0	96.3	113.6	94.8	78.7	69.2
Calculated	25.03S 129.9E				75.8	86.8	95.4	100.3	119.1	98.9	82.8	73.2
Measured Mean					78.3	90.9	97.7	104.7	123.2	102.7	85.3	74.7
STD DEV					3.9	3.6	4.3	4.5	5.3	4.0	4.1	4.4
Calculated Mean					78.6	90.7	100.1	105.5	123.8	103.7	86.4	75.4
STD DEV					2.5	2.9	3.2	3.4	3.7	3.0	2.9	2.1
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ %					-0.4	+0.2	-2.5	-0.7	-0.5	-1.0	-1.4	-1.0
Correlation					0.662	0.780	0.724	0.784	0.850	0.833	0.657	-0.594

Table 6. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) and (26-62S)—Clear

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353
Measured	Lajes, Azores	790711	8.99°	63 nmi	78.5	88.4	95.6	102.5	120.0	99.7	84.8	73.2
Calculated	38.73N 27.08W				83.4	95.8	105.2	110.4	125.7	107.8	91.6	80.3
Measured	Griefswald, Denmark	791001	9.05°	18 nmi	72.2	81.7	89.1	95.8	111.9	93.6	78.7	67.6
Calculated	54.10N 13.38E				71.7	82.4	90.3	95.0	108.8	94.2	78.2	69.2
Measured	OMSK, USSR	790314	0°	59 nmi	68.3	77.9	82.3	87.1	92.4	86.5	73.2	65.8
Calculated	54.93N 73.40E				70.7	80.0	86.5	90.3	97.8	89.1	76.6	68.5
Measured	OMSK, USSR	790505	27.27°	45 nmi	75.1	85.4	90.6	95.9	108.2	94.2	80.6	71.8
Calculated	54.93N 73.40E				72.7	82.5	89.7	93.9	105.5	92.5	79.0	70.3
Measured	Churchill, Mon, CN	790816	13.52°	80 nmi	73.1	84.2	89.5	95.5	110.7	94.4	78.6	70.0
Calculated	58.75N 94.07W				76.6	87.6	96.0	100.7	115.6	98.7	83.9	73.9
Measured	W. Palm Beach, FL	790322	-13.63°	63 nmi	76.8	88.4	94.1	100.1	116.1	98.4	83.0	73.3
Calculated	26.68N 80.10W				81.0	92.2	100.6	105.4	120.6	103.3	88.2	78.3
Measured	W. Palm Beach, FL	790408	-18.10°	33 nmi	74.0	86.3	92.0	98.9	118.3	98.1	80.1	70.6
Calculated	26.68N 80.10W				77.1	89.2	98.8	104.2	123.2	102.9	84.7	74.1
Measured	Boothville, LA	790618	-32.08°	92 nmi	81.9	96.3	104.0	111.6	129.4	109.3	90.2	77.6
Calculated	29.33N 89.40W				83.9	95.8	105.7	111.1	130.6	108.9	91.3	80.0
Measured	Wallops, VA	790502	-13.58°	79 nmi	76.7	89.1	95.4	101.7	117.0	100.0	83.4	72.8
Calculated	37.85N 75.48W				76.7	89.7	100.0	105.9	124.9	104.5	85.0	73.3
Measured	Wallops, VA	790518	-4.52°	92 nmi	79.7	91.3	98.0	104.0	118.5	102.1	86.2	75.1
Calculated	37.85N 75.48W				75.0	86.9	96.2	101.5	117.0	99.8	82.8	71.9
Measured	Sterling, VA	790518	-13.63°	99 nmi	74.1	86.3	92.4	98.8	115.3	98.0	80.0	69.9
Calculated	38.98N 77.47W				74.9	86.7	96.0	101.4	116.7	99.7	82.6	71.7
Measured	Wallops, VA	790916	31.91°	23 nmi	74.9	87.2	93.3	100.0	115.6	98.4	81.1	70.9
Calculated	37.85N 75.48W				78.5	90.9	100.8	106.2	121.0	104.0	87.1	75.1
Measured	Wallops, VA	790920	-32.14	26 nmi	77.2	89.6	96.2	102.9	120.1	101.1	84.3	74.1
Calculated	37.85N 75.48W				82.9	94.7	103.5	108.7	126.8	107.0	89.6	80.5
Measured	Salem, IL	790516	-31.91°	97 nmi	75.2	87.6	93.1	99.6	116.0	98.4	81.4	73.1
Calculated	38.65N 88.97W				78.3	88.9	96.6	101.2	116.4	99.6	84.7	76.0
Measured	Chatham, MA	790503	-22.74°	87 nmi	71.3	81.5	86.2	91.7	107.5	90.8	76.6	67.8
Calculated	41.67N 69.97W				73.6	85.3	94.3	99.5	115.0	98.1	81.2	70.6
Measured	Chatham, MA	790917	9.05°	92 nmi	76.6	90.7	96.6	103.5	119.0	104.3	85.7	74.4
Calculated	41.67N 69.98W				81.8	93.6	102.6	107.6	121.5	105.0	89.8	78.8
Measured	Cape Canaveral, FL	790130	-4.52°	47 nmi	79.3	89.8	94.8	100.0	112.8	98.0	85.2	77.7
Calculated	28.47N 80.55W				74.6	84.6	92.3	96.7	110.4	95.1	81.1	72.1
Measured	Porto Allegro, BZ	790320	4.52°	49 nmi	77.7	91.7	98.1	104.9	121.3	102.9	84.8	75.0
Calculated	30.0S 51.18W				81.5	93.8	103.3	108.5	125.7	106.2	89.7	78.3
Measured	Porto Allegro, BZ	790505	27.33°	71 nmi	75.0	89.1	96.6	103.3	120.5	102.0	83.3	70.2
Calculated	30.0S 51.18W				78.5	90.8	100.3	105.6	120.6	103.7	86.7	75.3
Measured	Ship Charlie	790507	-8.99°	48 nmi	70.3	81.1	85.9	91.7	105.1	90.9	76.0	67.0
Calculated	52.7N 35.5W				73.2	83.3	90.8	95.3	109.3	94.0	79.5	70.8
Measured	Ship Charlie	790628	9.05°	93 nmi	72.8	84.4	89.6	95.6	109.3	94.8	78.5	69.6
Calculated	52.7N 35.5W				72.7	82.8	90.3	94.8	109.6	93.8	78.7	70.3
Measured Mean					75.3	87.0	93.0	99.3	114.6	97.9	81.7	71.8
STD DEV					3.3	4.3	4.9	5.4	7.6	5.2	4.0	3.3
Calculated Mean					77.1	88.5	97.1	102.1	117.3	100.4	84.4	74.3
STD DEV					4.1	4.8	5.6	6.0	8.1	5.6	4.6	3.9
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ %					-2.4	-1.6	-4.4	-2.8	-2.3	-2.5	-3.3	-3.4
STD DEV					3.7	3.4	3.5	3.3	3.1	3.1	3.6	3.9
Correlation:					0.697	0.779	0.807	0.834	0.902	0.835	0.758	0.653

Table 7. Comparison of Measured With Calculated Radiances—Arctic (62-90N)—Clear

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353
Measured	Thule AB, GL	790205	-9.0	18 nmi	64.6	69.6	72.3	74.4	75.4	73.6	68.2	62.7
Calculated	76.52N 68.83W				68.3	73.5	76.2	77.9	77.7	76.6	71.8	66.8
Measured	Thule AB, GL	790205	-4.5	36 nmi	63.8	68.0	70.4	72.0	71.6	70.8	66.8	62.2
Calculated	76.52N 68.83W				68.3	73.5	76.2	77.9	77.7	76.6	71.8	66.8
Measured	Thule AFB, GL	790205	-13.6	41 nmi	64.9	69.3	71.4	72.6	73.5	72.1	67.8	61.9
Calculated	76.52N 68.83W				68.3	73.5	76.2	77.9	77.7	76.6	71.8	66.8
Measured	Khatanga, USSR	790418	18.0	75 nmi	68.6	76.9	80.6	84.8	88.0	83.5	73.0	65.3
Calculated	71.98N 102.47E				70.9	78.7	83.9	86.6	88.5	85.0	76.2	68.9
Measured	Khatanga, USSR	790419	13.5	67 nmi	68.7	75.7	78.9	82.0	84.3	81.1	72.9	65.9
Calculated	71.98N 102.47E				69.0	76.7	81.8	84.6	86.8	83.2	74.2	67.1
Measured	Alert, NT, CN	790314	-27.4	23 nmi	70 6	76.5	78.6	80.2	76.7	78.2	75.2	68.8
Calculated	82.5N 62.33W				70.4	77.2	81.4	83.2	81.8	81.8	75.8	68.4
Measured	Alert, NT, CN	790321	-22.7	54 nmi	66.2	70.9	73.2	74.6	72.0	73.6	69.7	64.3
Calculated					66.9	72.6	75.9	77.4	76.8	76.0	71.0	65.5
Measured	Alert, NT, CN	790326	-27.3	64 nmi	67.2	74.4	77.7	80.6	79.7	79.5	71.5	65.4
Calculated					68.7	75.7	80.0	82.3	81.5	80.8	73.6	67.0
Measured	Alert, NT, CN	790326	-32.0	98 nmi	67.4	74.7	78.0	80.7	80.6	79.6	71.3	65.8
Calculated					68.7	75.7	80.0	82.3	81.5	80.8	73.6	67.0
Measured Mean:					66.9	72.9	75.7	78.0	78.0	76.9	70.7	64.7
STD DEV					2.2	3.4	3.8	4.6	5.6	4.5	2.8	2.2
Calculated Mean:					68.8	75.2	79.1	81.1	81.1	79.6	73.3	67.1
STD DEV					1.2	2.1	3.0	3.4	4.2	3.3	1.9	1.0
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ %					-2.8	-3.2	-4.5	-4.0	-4.0	-3.5	-3.7	-3.7
Correlation:					0.698	0.919	0.961	0.969	0.961	0.964	0.881	0.524

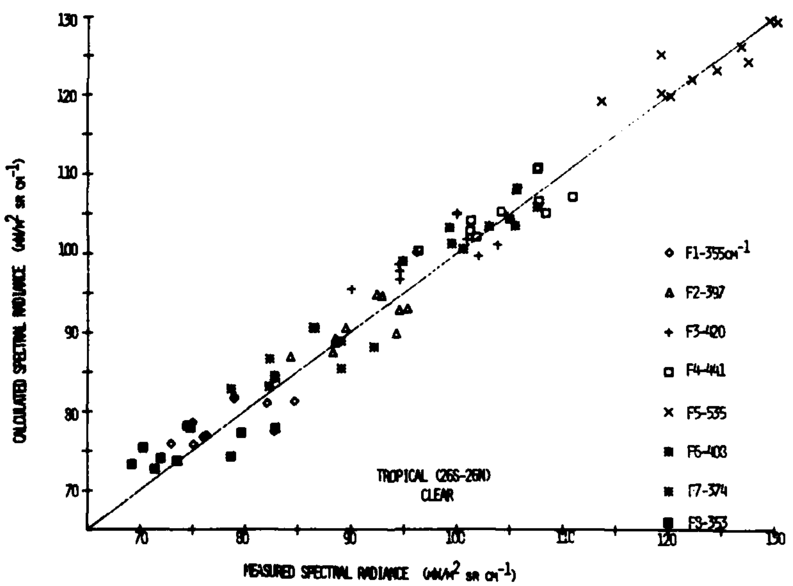

Figure 4. Measured and Calculated Clear Column Radiances for DMSP SSH H_2O Channels—Tropical

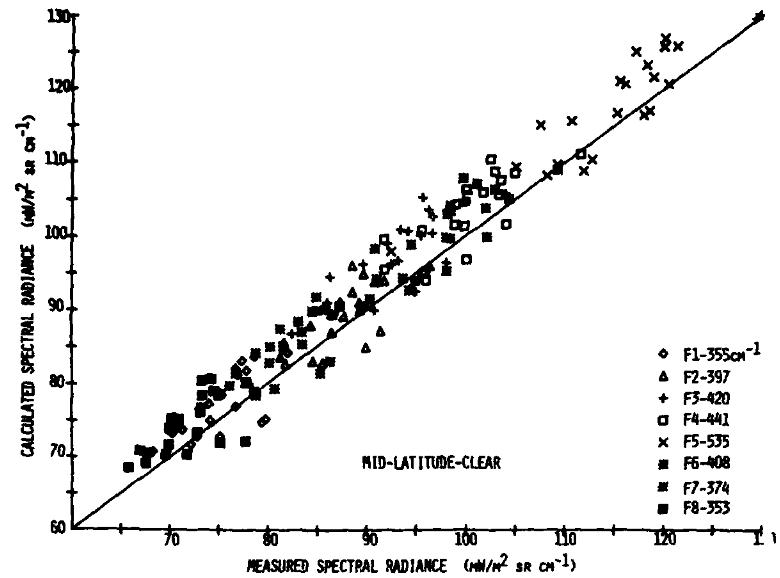

Figure 5. Measured and Calculated Clear Column Radiances for DMSP SSH H_2O Channels—Mid-latitude

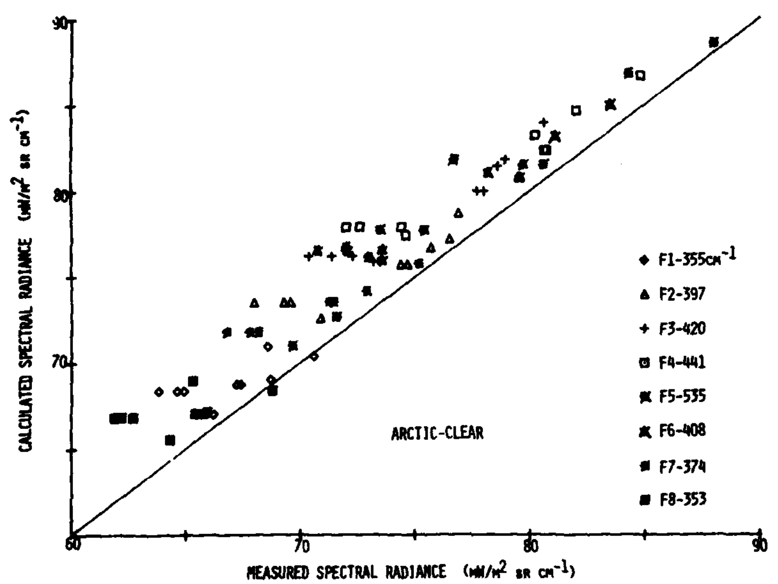

Figure 6. Measured and Calculated Clear Column Radiances for DMSP SSH H_2O Channels—Arctic

6.2 Cloud Contaminated Water Vapor Radiance Comparison

The colocated cloud contaminated cases selected for comparison are listed in Table 8 (Tropical), Table 9 (Mid-latitude—Low Clouds), Table 10 (Mid-latitude—High overcast) and Table 11 (Arctic). The 29 cloud contaminated cases—Tropical (5), Mid-latitude–Low Clouds (11), Mid-latitude–High overcast (7), and Arctic (6) were selected based again on the surface reports and the 3D NEPH data. In a few cases cloud conditions from 3D NEPH data were not available but are listed. In these tables, the row designated calculated-clear means that the transmittance calculations were carried out as if there were no clouds present. In the case where the transmittance calculations were computed and an effective cloud layer was determined in the row designated calculated-cloud at some height, the following assumptions were made: (1) the cloud has an emissivity of 1.00 and is constant over the width of the filter function, (2) the cloud amount is 100 percent and fills the field of view of the instrument, (3) T_s, the surface temperature in Eq. (1) is replaced by T_c, the cloud top temperature, and (4) the radiance percentage deviation is minimized by iterations for DMSP channel F5-535 cm^{-1} only, and (5) the effective cloud level found for F5-535 cm^{-1} is valid for all the DMSP water vapor channels.

Figures 7, 8, 9, and 10 show the results of the comparison in graphical form for the calculated clear-cloud contaminated for Tropical, Mid-latitude-Low Clouds, Mid-latitude—High overcast and Arctic, respectively. As should be expected, in the majority of cases, the calculated exceeds the satellite measured water vapor radiances. The higher the effective cloud layer, the greater the deviation. This should be expected since the upwelling radiation is coming from a higher level in the atmosphere. However, it is surprising that even with the cloud contamination there are a few comparisons showing a slight positive percentage deviation. For example in Table 8 and Figure 9, the comparison radiance data for Bangkok would indicate a clear column condition but the 3D NEPH data showed a broken cirrus stratus condition 1.5 to 4.0 km thick. No effective cloud layer calculations were performed for Bangkok because the radiance data for F5-535 cm^{-1} was already maximized with minimum percentage deviation. Also shown in Table 8, the greatest discrepancy found in this study was Ponope, Caroline Islands. The range of discrepancies range from -61 percent for F8-353 cm^{-1}, the most opaque channel, to -182 percent for F5-535 cm^{-1}, the most transparent channel. Although there are only five cases in the Tropics used for comparison, the cloud retrievals are disappointing when the effective cloud layer is compared directly to the cloud conditions reported in the 3D NEPH data. For example, in Table 8 see Bangkok on 790403 and either Truk or Ponape. The effective cloud layer calculations do not even come close to the actual cloud conditions being reported by the 3D NEPH data. However, the relationship between the measured and calculated radiances for an effective cloud layer in the Tropics is greatly improved as shown graphically in Figure 11.

Table 8. Comparison of Measured With Calculated Radiances—Tropical (0-26N)—Calculated Clear and Clouds

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353	Cloud Level	Conditions Amount
Measured	Bangkok, TH	790329	27.44	68 nmi	73.2	85.0	90.3	96.9	115.5	95.4	79.2	69.9	12.0 km	0.55
Calc-Clear	13.73N 100.5E				74.2	85.0	93.2	98.0	115.4	96.7	81.0	81.0		
Calc-Cloud at N/A					----	----	----	----	-----	----	----	----		
Measured	Bangkok, TH	790403	13.52	81 nmi	81.6	94.9	101.9	109.3	125.2	107.0	89.1	76.6	12.0	0.75
Calc-Clear	13.73N 100.5E				81.0	93.2	102.8	108.1	127.5	106.0	89.0	78.0		
Calc-Cloud at N/A					----	----	-----	-----	-----	-----	----	----		
Measured	Brownsville, T	790206	-9.05	69 nmi	69.2	72.8	74.0	75.0	76.5	74.4	71.5	68.0	10.7	0.25
Calc-Clear	25.9N 92.43W				72.0	82.2	90.0	94.5	109.6	93.2	78.5	69.5	4.3	1.00
Calc-Cloud at 8.6 km					67.4	72.6	75.6	77.0	76.9	75.8	71.0	66.2		
Measured	TRUK, KA	790317	27.50	42 nmi	66.5	73.5	76.2	79.0	82.4	78.5	70.2	64.2	4.3	0.10
Calc-Clear	7.47N 151.8SE				73.5	83.3	90.4	94.6	109.5	93.3	79.4	71.2	1.5	0.90
Calc-Cloud at 9.5 km					70.7	76.9	80.4	82.2	83.2	80.6	74.9	69.4		
Measured	Ponape, KA	790409	-9.05	31 nmi	46.6	46.2	45.3	44.5	40.3	45.8	46.4	46.3	12.2	0.65
Calc-Clear	6.97N 158.22E				77.2	87.7	95.6	101.4	113.5	98.3	84.0	74.6	7.9	1.00
Calc-Cloud at 15.0 km					45.4	46.0	45.8	45.3	40.4	46.0	45.8	45.3		

Table 9. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) Calculated Clear and Effective Cloud Layer Less Than 4 km

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353	Cloud Level	Conditions Amount
Measured	Oslo, Norway	790328	4.46°	90 nmi	71.5	80.4	84.8	89.4	96.8	88.0	76.6	68.5	N/A	
Calc-Clear	60.2N 11.1E				71.7	81.7	89.1	93.4	105.4	92.1	78.0	69.3		
Calc-Cloud at 2.0 km					71.4	80.3	86.7	90.3	97.4	88.9	77.3	69.1		
Measured	Lerwick, UK	790326	-13.52°	64 nmi	77.7	87.1	91.4	95.1	100.1	92.7	83.5	75.1	1.1	0.80
Calc-Clear	60.13N 1.18W				74.2	85.0	93.2	97.7	109.0	95.9	81.7	71.2		
Calc-Cloud at 2.5 km					73.8	83.8	91.0	94.8	101.5	92.8	80.9	71.0		
Measured	Lerwick, UK	790406	4.46°	31 nmi	70.7	80.1	84.6	89.1	98.2	87.9	75.8	67.0	2.1 km	0.30
Calc-Clear					71.8	81.4	88.3	92.5	106.0	91.3	77.7	69.6	1.1	0.95
Calc-Cloud at 2.2 km					71.7	80.7	86.9	90.5	98.2	89.1	77.5	69.6		
Measured	W. Palm Beach, FLA	790403	0°	86 nmi	75.5	89.4	96.7	104.5	117.5	103.2	83.4	70.1	3.0	1.00
Calc-Clear	26.68N 80.1W				79.8	92.9	103.3	109.0	125.3	106.9	88.4	76.2		
Calc-Cloud at 4.0 km					79.3	91.6	101.1	106.2	118.8	104.0	87.6	76.0		
Measured	Cape Hatteras, NC	790823	13.52°	92 nmi	72.1	80.9	87.8	93.8	111.5	92.1	78.0	67.9	12.2 km	0.40
Calc-Clear	35.27N 75.55W				74.2	86.0	95.2	100.5	118.0	99.3	81.5	71.2	1.1	0.15
Calc-Cloud at 3.75 km					74.1	85.5	94.2	99.2	111.4	97.8	81.4	71.2		
Measured	Cape Hatteras, NC	790816	4.46°	64 nmi	73.6	84.6	90.3	96.6	113.4	95.7	79.0	70.7	6.7 km	0.25
Calc-Clear					78.7	88.7	95.8	99.8	112.4	97.9	84.9	76.4		
Calc-Cloud at N/A					----	----	-----	-----	-----	-----	----	----		
Measured	Wallops, VA	790205	18.11°	31 nmi	74.5	83.2	89.1	94.3	108.0	92.3	80.1	71.1	N/A	
Calc-Clear	37.85N 75.48W				78.3	87.9	94.1	98.7	109.8	96.7	84.4	75.2		
Calc-Cloud at 1.4 km					78.2	87.5	93.4	97.7	105.6	95.5	84.3	75.1		
Measured	Wallops, VA	790205	4.53°	36 nmi	76.2	86.0	90.3	95.0	105.6	93.5	81.0	74.1	N/A	
Calc-Clear					78.0	87.9	95.0	99.0	109.8	96.9	84.5	75.7		
Calc-Cloud at 1.4 km					78.0	87.5	94.2	97.9	105.6	95.6	84.4	75.7		
Measured	Wallops, VA	790617	0°	74 nmi	78.2	89.9	95.3	101.5	117.6	99.3	84.3	75.2	7.9	0.25
Calc-Clear					82.7	93.6	101.5	106.0	121.9	103.7	89.4	80.3	1.5	0.85
Calc-Cloud at 3.0 km					82.7	93.4	101.0	105.3	117.6	102.9	89.4	80.3	0.3	0.95
Measured	Chatham, MA	790519	0°	82 nmi	70.5	81.9	87.1	93.3	108.7	92.6	76.1	68.0	12.2 km	0.90
Calc-Clear	41.67N 69.9W				75.4	88.1	97.9	103.5	119.7	101.9	83.6	72.0		
Calc-Cloud at 3.5 km					74.9	86.3	94.8	99.6	110.0	97.6	82.5	71.8		
Measured	Chatham, MA	790703	0°	91 nmi	72.8	83.8	88.7	94.3	108.4	93.1	78.7	70.4	9.1 km	0.20
Calc-Clear					78.5	88.6	96.0	100.1	113.6	97.8	85.1	76.1	4.3	0.20
Calc-Cloud at 3.6 km					78.5	88.4	95.6	99.6	109.4	97.3	85.1	76.1	1.1	0.20
Mean-Measured					73.9	84.3	89.6	95.2	107.6	93.7	79.7	70.7		
-Calc-Clear					76.7	87.4	95.4	100.0	113.7	98.2	83.6	73.9		
-Calc-Cloud					76.5	86.7	94.1	98.3	108.0	96.3	83.2	73.8		
$\frac{(Meas-Calc)}{Meas}$ Clear %					-3.7	-3.7	-6.4	-5.1	-5.7	-4.9	-4.9	-4.5		
$\frac{(Meas-Calc)}{Meas}$ Cloudy %					-3.4	-2.8	-5.0	-3.2	-0.3	-2.8	-4.4	-4.4		

Table 10. Comparison of Measured With Calculated Radiances—Mid-latitude (26-62N) Calculated Clear and High Overcase

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353	Cloud Level	Conditions Amount
Measured	Lerwick, UK	790207	9.05°	75 nmi	65.2	70.8	73.3	75.1	76.0	74.4	68.8	63.1	6.6 km	'1.00
Calc-Clear	60.13N 1.18W				66.8	76.6	83.8	88.2	101.4	87.4	73.0	64.3		
Calc-Cloud at 5.6 km					64.5	70.6	74.3	76.1	76.7	75.1	68.9	63.0		
Measured	Lerwick, UK	790302	18.16°	68 nmi	65.4	70.6	73.0	74.8	75.5	74.3	68.9	63.1	6.6	1.00
Calc-Clear	60.13N 1.18W				67.9	77.3	84.3	88.4	100.5	87.3	74.0	65.5		
Calc-Cloud at 6.5 km					65.0	70.6	73.8	75.4	75.4	74.3	68.9	63.7		
Measured	Stanwell, UK	790302	27.38°	85 nmi	64.4	68.7	70.4	71.6	72.1	71.2	66.9	62.3	7.8	1.00
Calc-Clear	56.43N 2.87W				69.0	78.8	86.0	90.3	103.1	89.3	75.2	66.5		
Calc-Cloud at 8.1 km					64.5	69.3	71.8	73.0	72.1	72.1	67.8	63.5		
Measured	Marssarssuaq, GL	790306	18.22°	70 nmi	56.8	56.0	54.7	53.4	51.4	55.1	57.1	56.1	10.5	0.65
Calc-Clear	61.18N 45.43W				67.1	76.1	82.6	86.5	96.7	85.7	72.7	64.9	7.8	1.00
Calc-Cloud at 9.1 km					54.4	55.8	55.9	55.7	51.5	55.8	55.1	54.3		
Measured	Griefswald, DEN	790316	-27.44°	47 nmi	58.9	62.0	62.7	63.2	62.0	64.7	60.7	58.7	12.0	0.65
Calc-Clear	54.1N 13.38E				70.7	80.3	87.4	91.6	103.4	90.2	76.9	68.3	7.8	1.00
Calc-Cloud at 8.5 km					60.1	62.6	63.1	63.8	60.9	63.4	61.4	60.0		
Measured	Huntington, W.VA	790402	-18.16°	72 nmi	57.0	58.7	58.5	58.1	55.7	59.2	58.4	56.8	10.5	0.75
Calc-Clear	38.37N 82.55W				71.8	81.1	87.9	92.0	106.0	90.8	77.5	69.6	6.6	0.95
Calc-Cloud at 11.0 km					56.8	58.8	59.3	59.3	55.7	59.2	58.0	56.5	5.4	1.00
Measured	Salem, IL	790401	-13.58°	36 nmi	55.0	55.4	55.0	54.2	50.5	55.6	55.4	54.0	12.0	0.65
Calc-Clear	38.65N 88.97W				71.6	81.1	87.9	91.9	104.7	90.5	77.6	69.4	7.8	1.00
Calc-Cloud at 11.0 km					53.7	55.3	55.5	55.3	51.2	55.5	54.6	53.6		
Mean-Measured					60.4	63.2	63.9	64.3	63.3	64.9	62.3	59.2		
-Calc-Clear					69.3	78.8	85.7	89.8	102.3	88.7	75.3	66.9		
-Calc-Clouds					59.9	63.3	64.8	65.5	63.4	65.1	62.1	59.2		
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ Clear %					-14.7	-24.7	-34.1	-39.7	-61.6	-36.7	-20.9	-13.0		
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ Clouds %					0.8	-0.2	-1.4	-1.9	-0.2	-0.3	+0.3	0		

Table 11. Comparison of Measured With Calculated Radiances—Arctic (62-90N) Calculated Clear and Clouds

	Location	Date	θ	Distance	F1 355	F2 397	F3 420	F4 441	F5 535	F6 408	F7 374	F8 353
Measured	Thule AB, GL	790204	0°	5 nmi	61.6	63.4	63.2	62.2	60.6	63.2	62.8	60.6
Calc-Clear	76.52N 68.83W	(13536)			66.8	72.6	75.9	78.2	79.3	77.0	70.6	64.9
Calc-Cloud at 4.5 km					60.7	63.3	64.0	64.2	61.1	63.7	62.1	60.5
Measured	Thule AB, GL	790294	-4.5°	27 nmi	61.9	64.2	64.1	63.5	62.1	64.3	63.6	61.2
Calc-Clear		(13536)			66.8	72.6	75.9	78.2	79.3	77.0	70.6	64.9
Calc-Cloud at 4.0 km					61.6	64.5	65.5	65.9	63.2	65.3	63.3	61.3
Measured	Thule AB, GL	790204	+4.5°	37 nmi	63.0	66.2	66.9	67.6	67.1	67.3	64.7	62.6
Calc-Clear		(13536)			66.8	72.6	75.9	78.2	79.3	77.0	70.6	64.9
Calc-Cloud at 3.0 km					63.3	66.8	68.4	69.2	67.3	68.4	65.5	62.7
Measured	Thule AB, GL	790204	0°	16 nmi	61.8	63.6	63.9	63.0	61.4	63.6	63.5	60.7
Calc-Clear		(14537)			66.4	72.5	76.2	78.2	79.2	77.0	70.5	65.0
Calc-Cloud at 4.25 km					61.0	63.6	64.4	64.7	61.6	64.2	62.5	60.8
Measured	Thule AB, GL	792004	+4.5°	16 nmi	63.2	66.6	67.5	67.6	67.1	67.2	65.4	62.5
Calc-Clear		(14537)			66.4	72.5	76.2	78.2	79.2	77.0	70.5	65.0
Calc-Cloud at 2.5 km					63.5	67.2	68.9	69.6	67.6	68.9	69.8	62.9
Measured	Thule AB, GL	790204	-4.5°	50 nmi	62.0	63.6	64.3	63.7	61.9	64.3	63.1	60.7
Calc-Clear		(14537)			66.4	72.5	76.2	78.2	79.2	77.0	70.5	65.0
Calc-Cloud at 4.25 km					61.0	63.6	64.4	64.7	61.6	64.2	62.5	60.8
Mean-Measured					62.25	64.6	65.0	64.6	63.4	65.0	63.85	61.4
-Calc-Clear					66.6	72.55	76.05	78.2	79.25	77.0	70.55	64.95
-Calc-Clouds					61.85	64.8	65.9	66.4	63.7	65.8	63.6	61.5
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ Clear %					-7.0	-12.3	-17.0	-21.1	-25.0	-18.5	-10.5	-5.8
$\frac{\text{(Meas-Calc)}}{\text{Meas}}$ Clouds %					+0.6	-0.3	-1.4	-2.8	-0.5	-1.2	+0.4	-0.2

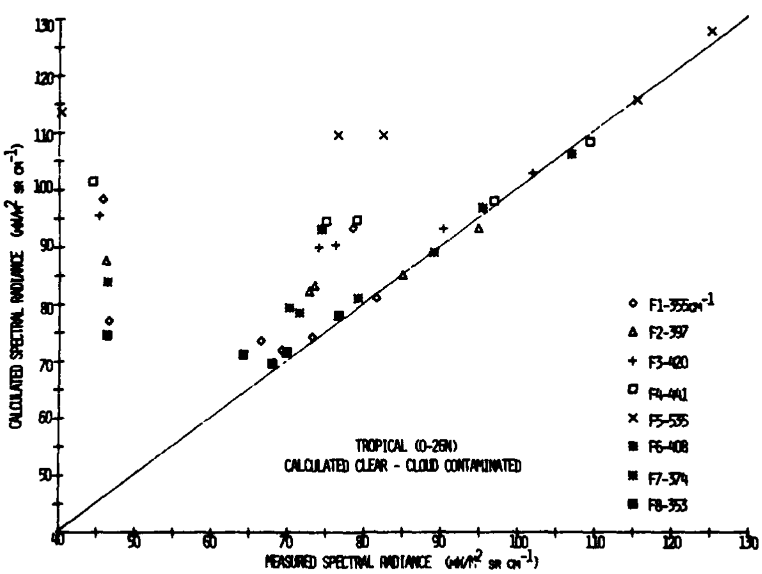

Figure 7. Measured and Calculated Clear Column—Cloud Contaminated Radiances for DMSP SSH H_2O Channels—Tropical

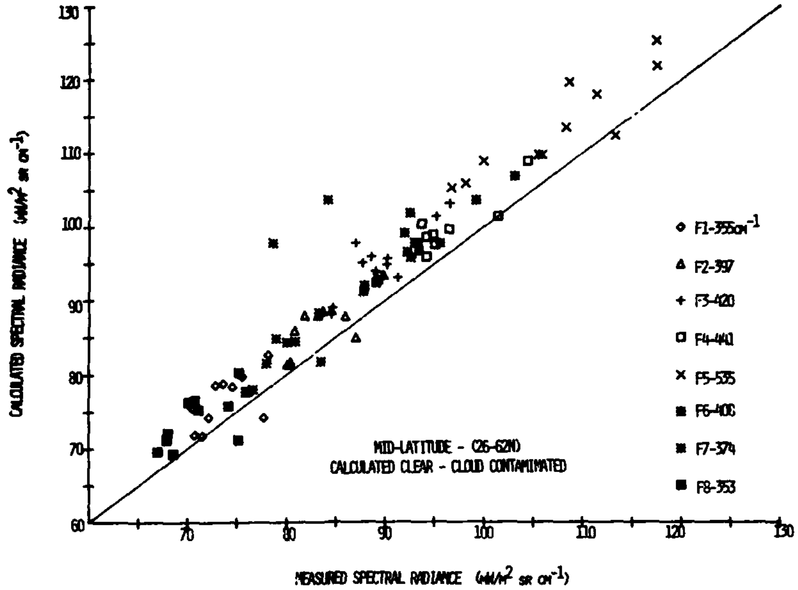

Figure 8. Measured and Calculated Clear Column—Cloud Contaminated Low Cloud Radiances for DMSP SSH H_2O Channels—Mid-latitude

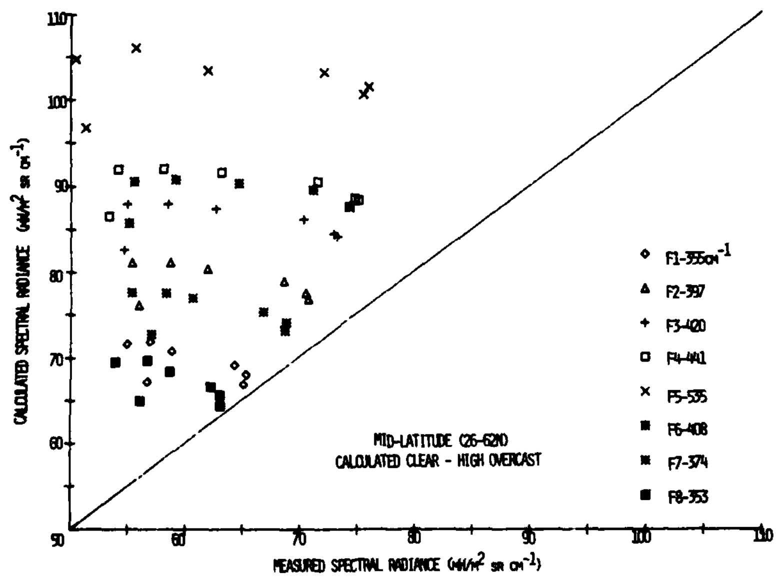

Figure 9. Measured and Calculated Clear Column—Cloud Contaminated High Overcast Radiances for DMSP SSH H_2O Channels—Mid-latitude

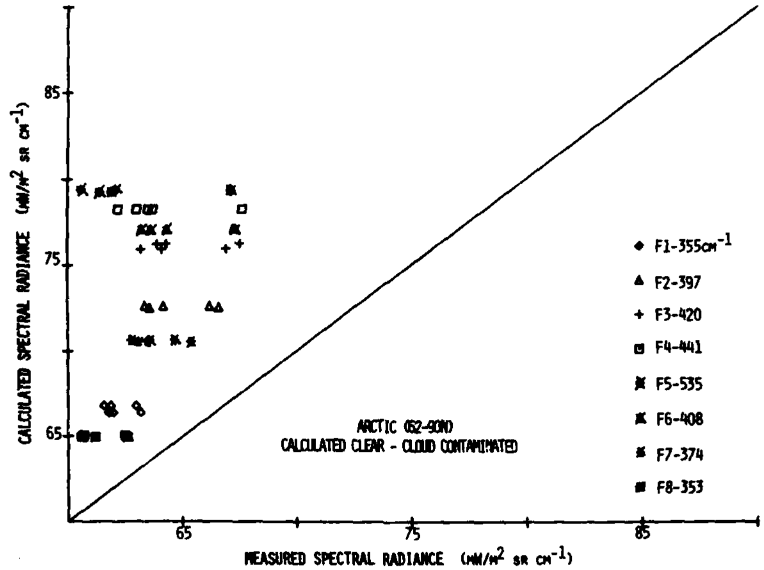

Figure 10. Measured and Calculated Clear Column—Cloud Contaminated Radiances for DMSP SSH H_2O Channels—Arctic

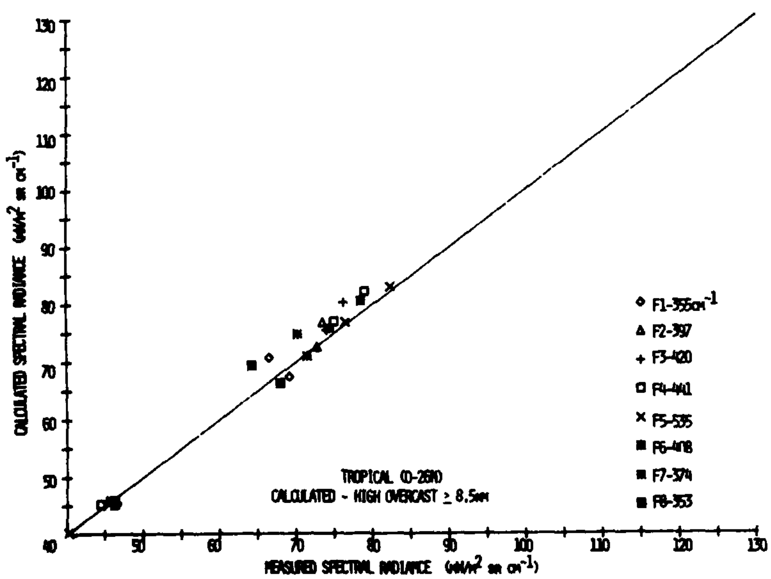

Figure 11. Measured and Calculated High Overcast Radiances for DMSP SSH H_2O Channels—Tropical

The comparison of measured with calculated radiances in the cloud contaminated cases for the Mid-latitude belt was sub-divided into a low and high cloud atmospheric condition. The low cloud category was arbitrarily chosen based on the calculation of an effective cloud layer at or below 4 km or approximately the 600 mb level in the atmosphere. The actual cloud conditions both in amounts and levels as obtained from the 3D NEPH data are quite variable as can be seen in Table 9. The Mid-latitude—High overcast category shows a more uniform type of cloud conditions, as seen in Table 10.

The Mid-latitude—Low-effective cloud layer comparison is listed in Table 9 and shown graphically in Figure 8. The mean percentage deviations are negative for all DMSP channels. The range is -3.7 percent to -5.7 percent for the cloud contaminated cases which is very similar to the range of -1.6 percent to -4.4 percent for the clear column comparison shown in Table 6. Also, it would be very difficult to see any significant differences between Figure 5—Mid-latitude Clear and Figure 8—Mid-latitude Calculated Clear-Cloud contaminated. The cloud retrievals only show a slight improvement as shown in Table 9 and Figure 12. The maximum improvement is shown in DMSP channel F5-535 cm^{-1}, a reduction from -5.7 to -0.3 percent, and this improvement is due to the design of the cloud retrieval calculation. There is very little improvement in the more opaque water vapor channels, that is, F8-353 cm^{-1} and F1-355 cm^{-1}. It appears from this analysis that the DMSP water vapor channels cannot distinguish between *clear and low cloud contamination.* Low cloud contamination being an overcast below 3 or 4 km or lower than the 600 to 700 mb atmospheric level.

On the other hand, the Mid-latitude—High overcast comparison listed in Table 10 and shown graphically in Figure 9 shows a definite negative discrepancy between the measured and calculated water vapor radiances. The range of negative deviations is -13.0 percent for F8-353 cm^{-1} to -61.6 percent for F5-535 cm^{-1}. As should be expected, there is a definite negative discrepancy as shown both in Tables 10 and Figure 9. The cloud retrievals show an improvement in the comparison of effective cloud layer to the cloud conditions reported in the 3D NEPH data for the Mid-latitude—High overcast category. The cloud retrievals calculations in the measured and calculated radiance comparison show a large improvement as shown in Table 10 and Figure 13. The negative deviation for channel F5-535 cm^{-1} is reduced from -61.6 percent to -0.2 percent and for channel F8-353 cm^{-1} from -13.0 percent to 0 percent.

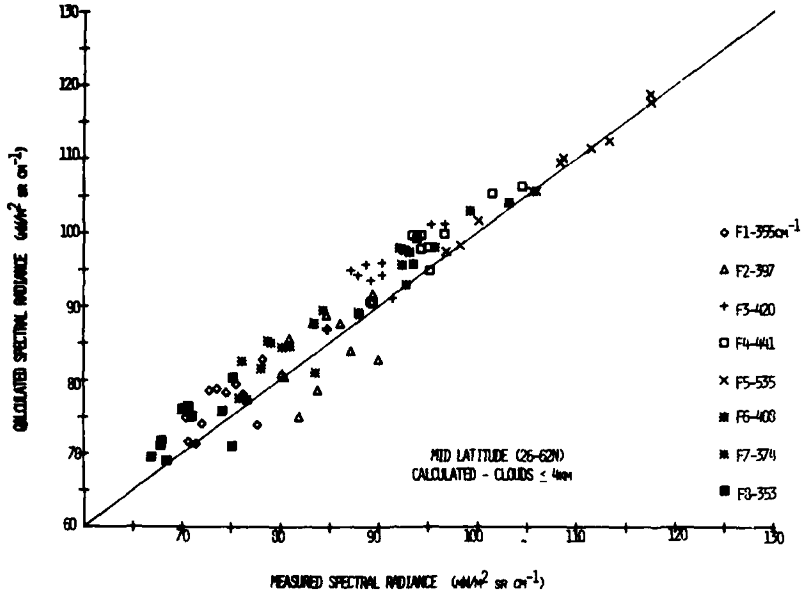

Figure 12. Measured and Calculated Low Overcast Radiances for DMSP SSH H_2O Channels—Mid-latitude

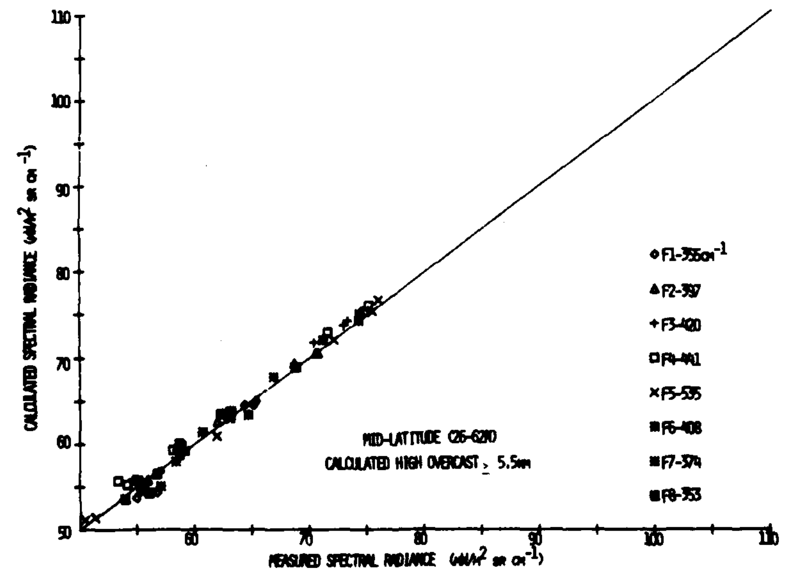

Figure 13. Measured and Calculated High Overcast Radiances for DMSP SSH H_2O Channels—Mid-latitude

Finally, in Table 11 and Figure 10, the comparison of measured with calculated radiances for the Arctic latitude belt is shown. There was no cloud information available so no actual comparisons could be made between the calculated effective and the actual cloud layer. This is also the only time when the comparison used both DMSP satellites, that is, 13536 and 14537. Figure 10 shows quite graphically the cloud contamination because of the large negative deviations of calculated being greater than the measured water vapor radiances. The range of negative deviations are -5.8 percent for F8-353 cm^{-1} and -25.0 percent for F5-535 cm^{-1}. The Arctic cloud retrievals are shown in Table 11 and Figure 14.

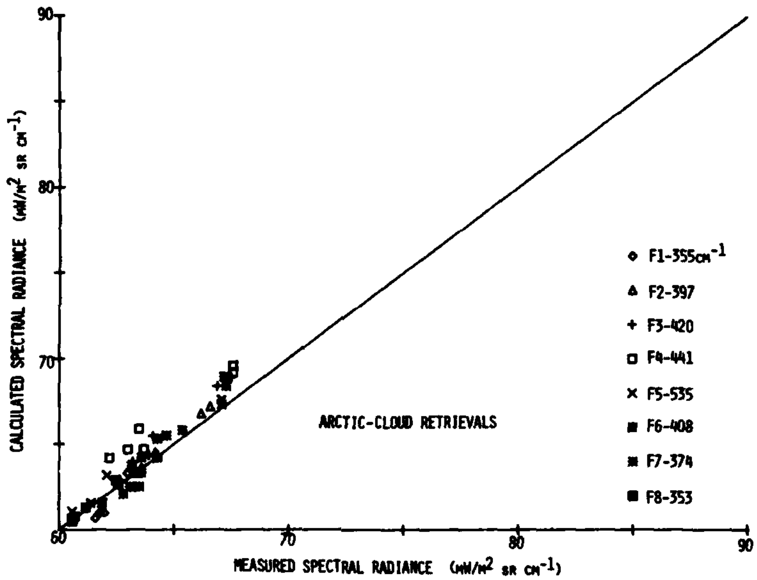

Figure 14. Measured and Calculated Overcast Radiances for DMSP SSH H_2O Channels—Arctic

7. CONCLUSIONS

Comparisons have been made between DMSP SSH H_2O measurements and classically-calculated water vapor radiances based on colocated in space and time radiosonde observations. Approximately 70 sets of radiance data were compared both in clear and cloud contaminated atmospheric conditions. In addition, the sets were divided into three latitude belts, that is, Tropical (26S-26N), Mid-latitude

(26-62N) and Arctic (62-90N). Systematic discrepancies, by approximately a 4:1 ratio, are shown for all of the DMSP SSH H_2O channels in comparison to the calculated water vapor radiances. The calculated radiances generally exceed the measured radiances with DMSP SSH F3-420 cm^{-1} channel showing the largest discrepancy. In the mean, the radiance comparison indicates a systematic discrepancy less than 5 percent for the clear column conditions. Results of this analysis, that is, calculated exceeds measured radiances, is in agreement with McClatchey's[3] results in his analysis of the 15 μm carbon dioxide channels.

In the clear column comparisons, the discrepancies appear to be latitudinally dependent. Smaller discrepancies are found in the Tropics and the larger discrepancies are found in the Arctic latitude belt. This may be due to the moisture and temperature profiles representing the latitude belts, that is, Tropics—more moisture—higher atmospheric temperature and Arctic—less moisture and colder atmospheric temperature. As would be expected, the discrepancies are larger in the cloud contaminated cases because the upwelling radiation is coming from the cloud top level. However, in the low cloud contamination (less than 600 mb) the discrepancies are very similar to the clear column comparisons. Thus it appears that the DMSP SSH H_2O channels cannot discriminate between low cloud contamination and clear column conditions. A cloud retrieval procedure was used to improve the relationship between the measured and calculated cloud contaminated water vapor radiances. However, when the calculated effective cloud level is compared to the 3D NEPH cloud conditions, the results are disappointing. In general, the effective cloud level is much higher than that given in the 3D NEPH data.

In view of these results, it appears that additional research should be done on the Forward Problem, that is, matching measurements with calculations. The single point or scan spot station comparison from Polar orbiting satellites has been disappointing. There is a definite need to delineate the Forward Problem discrepancy. Hopefully a study of spatial and temporal variations of the satellite radiance data and carefully selected "ground truth" sites will answer some of these discrepancies. It appears that a carefully designed research program using a geostationary satellite sounder such as the VISSR Atmospheric Sounder could provide some of the answers to the Forward Problem discrepancy.

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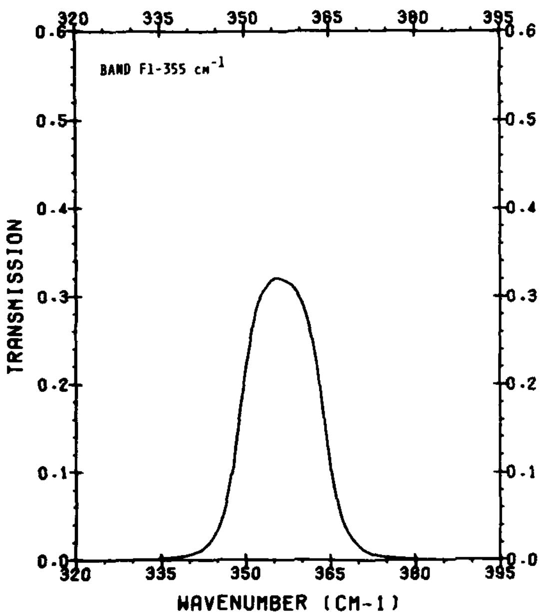
Appendix A

DMSP SSH H_2O Filter Transmission Curves and Digitized Filter Functions

Filter transmission curves and digitized filter functions for the eight (8) DMSP SSH water vapor channels are provided in Appendix A. These curves and the digitized filter functions were obtained from a Barnes Engineering Company's Report[9] and are valid for Flight II SSH package aboard spacecraft WC 13536 launched in July 1977. These curves were used to calculate the water vapor transmittances and the resulting weighting functions.

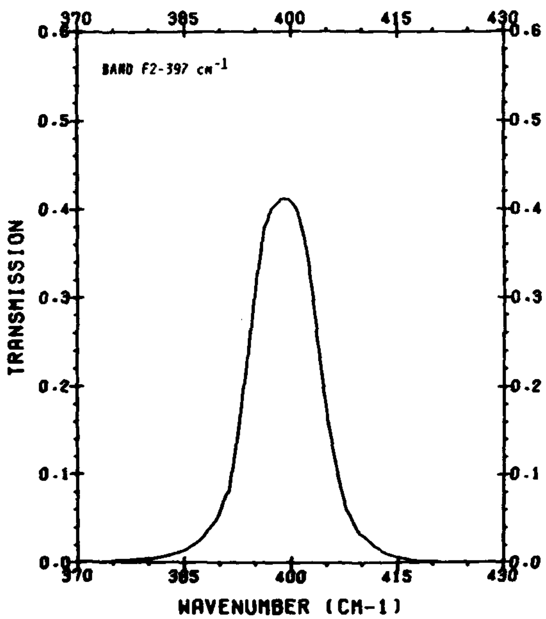
9. Barnes Engineering Co. (1976) Flight II-Supplementary Sensor H (SSH) Radiometric Performance, Report 2413-TA-012.



Band F1, 355 Wavenumber Channel

OMSP FILTER NO. 13536
355 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

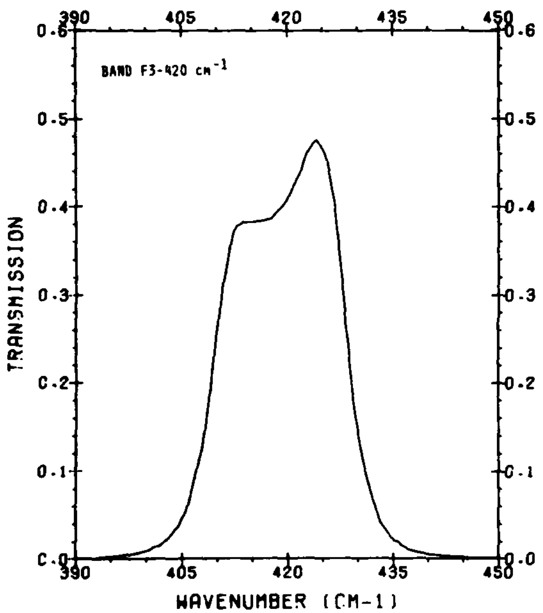
FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
334.5	.0011	358.5	.3100
335.0	.0012	359.0	.3050
335.5	.0015	359.5	.2970
336.0	.0017	360.0	.2900
336.5	.0020	360.5	.2800
337.0	.0024	361.0	.2700
337.5	.0028	361.5	.2570
338.0	.0033	362.0	.2420
338.5	.0039	362.5	.2240
339.0	.0045	363.0	.2000
339.5	.0053	363.5	.1740
340.0	.0063	364.0	.1400
340.5	.0074	364.5	.1250
341.0	.0087	365.0	.1020
341.5	.0100	365.5	.0830
342.0	.0120	366.0	.0690
342.5	.0150	366.5	.0550
343.0	.0180	367.0	.0450
343.5	.0220	367.5	.0380
344.0	.0270	368.0	.0320
344.5	.0320	368.5	.0270
345.0	.0390	369.0	.0230
345.5	.0490	369.5	.0190
346.0	.0610	370.0	.0160
346.5	.0770	370.5	.0130
347.0	.0950	371.0	.0110
347.5	.1020	371.5	.0095
348.0	.1320	372.0	.0079
348.5	.1500	372.5	.0070
349.0	.1820	373.0	.0063
349.5	.2030	373.5	.0056
350.0	.2260	374.0	.0051
350.5	.2440	374.5	.0045
351.0	.2650	375.0	.0041
351.5	.2820	375.5	.0037
352.0	.2930	376.0	.0033
352.5	.3000	376.5	.0030
353.0	.3060	377.0	.0027
353.5	.3100	377.5	.0024
354.0	.3150	378.0	.0021
354.5	.3180	378.5	.0019
355.0	.3200	379.0	.0017
355.5	.3210	379.5	.0015
356.0	.3200	380.0	.0014
356.5	.3190	380.5	.0012
357.0	.3180	381.0	.0011
357.5	.3160	381.5	.0010
358.0	.3140		



Band F2, 397 Wavenumber Channel

DMSP FILTER NO. 13536
397 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

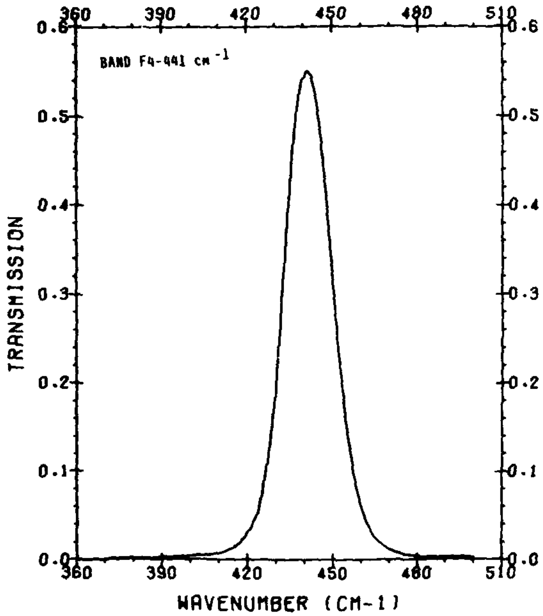
FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
375.0	.0010	398.5	.4110
375.5	.0012	399.0	.4120
376.0	.0014	399.5	.4110
376.5	.0016	400.0	.4070
377.0	.0018	400.5	.4010
377.5	.0020	401.0	.3910
378.0	.0023	401.5	.3730
378.5	.0027	402.0	.3570
379.0	.0030	402.5	.3300
379.5	.0035	403.0	.2980
380.0	.0040	403.5	.2620
380.5	.0046	404.0	.2300
381.0	.0052	404.5	.1950
381.5	.0060	405.0	.1620
382.0	.0068	405.5	.1400
382.5	.0078	406.0	.1150
383.0	.0089	406.5	.0940
383.5	.0100	407.0	.0770
384.0	.0120	407.5	.0620
384.5	.0130	408.0	.0550
385.0	.0150	408.5	.0460
385.5	.0180	409.0	.0380
386.0	.0200	409.5	.0330
386.5	.0230	410.0	.0310
387.0	.0260	410.5	.0270
387.5	.0300	411.0	.0230
388.0	.0370	411.5	.0190
388.5	.0420	412.0	.0170
389.0	.0460	412.5	.0140
389.5	.0530	413.0	.0120
390.0	.0630	413.5	.0100
390.5	.0750	414.0	.0089
391.0	.0880	414.5	.0076
391.5	.1050	415.0	.0065
392.0	.1200	415.5	.0056
392.5	.1560	416.0	.0048
393.0	.1890	416.5	.0041
393.5	.2150	417.0	.0035
394.0	.2480	417.5	.0030
394.5	.2890	418.0	.0026
395.0	.3220	418.5	.0022
395.5	.3480	419.0	.0019
396.0	.3780	419.5	.0016
396.5	.3950	420.0	.0014
397.0	.4000	420.5	.0012
397.5	.4030	421.0	.0010
398.0	.4070		



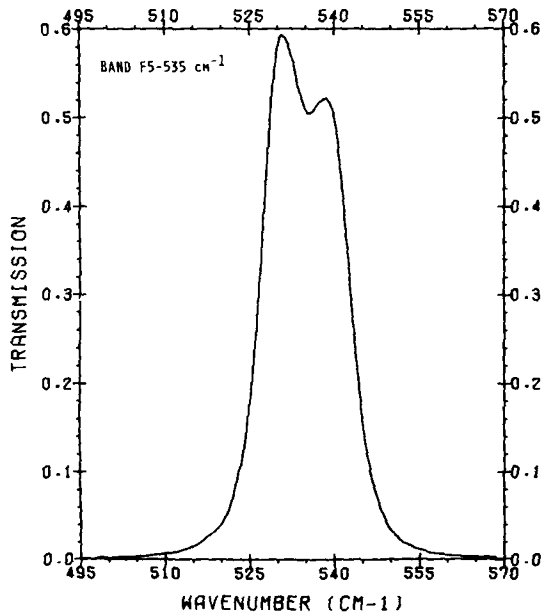
Band F3, 420 Wavenumber Channel

DMSP FILTER NO. 13536
420 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
393.0	.0010	412.5	.3770	432.0	.0650
393.5	.0012	413.0	.3790	432.5	.0550
394.0	.0014	413.5	.3820	433.0	.0420
394.5	.0017	414.0	.3820	433.5	.0360
395.0	.0020	414.5	.3820	434.0	.0300
395.5	.0023	415.0	.3820	434.5	.0250
396.0	.0028	415.5	.3830	435.0	.0210
396.5	.0034	416.0	.3830	435.5	.0200
397.0	.0040	416.5	.3840	436.0	.0160
397.5	.0045	417.0	.3859	436.5	.0140
398.0	.0052	417.5	.3860	437.0	.0110
398.5	.0060	418.0	.3910	437.5	.0100
399.0	.0070	418.5	.3950	438.0	.0080
399.5	.0082	419.0	.4000	438.5	.0078
400.0	.0090	419.5	.4050	439.0	.0070
400.5	.0120	420.0	.4120	439.5	.0062
401.0	.0130	420.5	.4200	440.0	.0056
401.5	.0140	421.0	.4290	440.5	.0050
402.0	.0180	421.5	.4360	441.0	.0047
402.5	.0220	422.0	.4500	441.5	.0042
403.0	.0260	422.5	.4600	442.0	.0039
403.5	.0320	423.0	.4660	442.5	.0035
404.0	.0350	423.5	.4720	443.0	.0032
404.5	.0440	424.0	.4750	443.5	.0030
405.0	.0510	424.5	.4780	444.0	.0027
405.5	.0630	425.0	.4620	444.5	.0025
406.0	.0800	425.5	.4500	445.0	.0023
406.5	.0950	426.0	.4270	445.5	.0021
407.0	.1100	426.5	.4030	446.0	.0020
407.5	.1250	427.0	.3600	446.5	.0018
408.0	.1500	427.5	.3200	447.0	.0017
408.5	.1800	428.0	.2740	447.5	.0016
409.0	.2140	428.5	.2400	448.0	.0015
409.5	.2500	429.0	.1980	448.5	.0014
410.0	.2750	429.5	.1600	449.0	.0013
410.5	.3100	430.0	.1350	449.5	.0012
411.0	.3300	430.5	.1120	450.0	.0011
411.5	.3520	431.0	.0950	450.5	.0010
412.0	.3700	431.5	.0800		



Band F4, 441 Wavenumber Channel



Band F5, 535 Wavenumber Channel

IHSP FILTER NO. 13536
441 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
371.0	.0010	397.0	.0030	423.0	.0500	449.0	.3660	475.0	.0068
371.5	.0010	397.5	.0031	423.5	.0550	449.5	.3450	475.5	.0064
372.0	.0010	398.0	.0032	424.0	.0620	450.0	.3260	476.0	.0062
372.5	.0011	398.5	.0033	424.5	.0680	450.5	.3040	476.5	.0059
373.0	.0011	399.0	.0034	425.0	.0750	451.0	.2800	477.0	.0055
373.5	.0011	399.5	.0036	425.5	.0850	451.5	.2500	477.5	.0052
374.0	.0011	400.0	.0037	426.0	.0940	452.0	.2410	478.0	.0050
374.5	.0012	400.5	.0038	426.5	.1030	452.5	.2240	478.5	.0048
375.0	.0012	401.0	.0039	427.0	.1130	453.0	.2070	479.0	.0046
375.5	.0012	401.5	.0041	427.5	.1240	453.5	.1900	479.5	.0043
376.0	.0012	402.0	.0042	428.0	.1350	454.0	.1750	480.0	.0041
376.5	.0012	402.5	.0043	428.5	.1400	454.5	.1570	480.5	.0039
377.0	.0013	403.0	.0044	429.0	.1620	455.0	.1440	481.0	.0037
377.5	.0013	403.5	.0045	429.5	.1750	455.5	.1310	481.5	.0036
378.0	.0013	404.0	.0046	430.0	.1920	456.0	.1220	482.0	.0034
378.5	.0014	404.5	.0047	430.5	.2120	456.5	.1100	482.5	.0033
379.0	.0014	405.0	.0048	431.0	.2320	457.0	.1000	483.0	.0032
379.5	.0015	405.5	.0050	431.5	.2510	457.5	.0930	483.5	.0031
380.0	.0015	406.0	.0052	432.0	.2700	458.0	.0840	484.0	.0030
380.5	.0015	406.5	.0054	432.5	.3030	458.5	.0770	484.5	.0030
381.0	.0015	407.0	.0055	433.0	.3250	459.0	.0700	485.0	.0029
381.5	.0015	407.5	.0056	433.5	.3450	459.5	.0640	485.5	.0029
382.0	.0015	408.0	.0058	434.0	.3700	460.0	.0580	486.0	.0028
382.5	.0015	408.5	.0062	434.5	.3950	460.5	.0530	486.5	.0028
383.0	.0015	409.0	.0064	435.0	.4150	461.0	.0480	487.0	.0028
383.5	.0016	409.5	.0066	435.5	.4360	461.5	.0440	487.5	.0027
384.0	.0017	410.0	.0070	436.0	.4570	462.0	.0400	488.0	.0027
384.5	.0017	410.5	.0073	436.5	.4740	462.5	.0370	488.5	.0027
385.0	.0017	411.0	.0076	437.0	.4920	463.0	.0340	489.0	.0027
385.5	.0018	411.5	.0082	437.5	.5050	463.5	.0310	489.5	.0027
386.0	.0018	412.0	.0088	438.0	.5150	464.0	.0290	490.0	.0027
386.5	.0018	412.5	.0094	438.5	.5260	464.5	.0270	490.5	.0026
387.0	.0019	413.0	.0100	439.0	.5330	465.0	.0250	491.0	.0026
387.5	.0019	413.5	.0110	439.5	.5400	465.5	.0230	491.5	.0026
388.0	.0020	414.0	.0115	440.0	.5420	466.0	.0210	492.0	.0025
388.5	.0020	414.5	.0122	440.5	.5470	466.5	.0200	492.5	.0025
389.0	.0021	415.0	.0130	441.0	.5500	467.0	.0190	493.0	.0025
389.5	.0021	415.5	.0150	441.5	.5490	467.5	.0170	493.5	.0025
390.0	.0022	416.0	.0160	442.0	.5470	468.0	.0160	494.0	.0025
390.5	.0023	416.5	.0170	442.5	.5450	468.5	.0150	494.5	.0025
391.0	.0023	417.0	.0180	443.0	.5390	469.0	.0140	495.0	.0026
391.5	.0024	417.5	.0200	443.5	.5330	469.5	.0130	495.5	.0026
392.0	.0024	418.0	.0220	444.0	.5250	470.0	.0120	496.0	.0026
392.5	.0024	418.5	.0230	444.5	.5160	470.5	.0110	496.5	.0026
393.0	.0025	419.0	.0250	445.0	.5030	471.0	.0110	497.0	.0026
393.5	.0025	419.5	.0280	445.5	.4880	471.5	.0098	497.5	.0027
394.0	.0026	420.0	.0310	446.0	.4750	472.0	.0093	498.0	.0027
394.5	.0026	420.5	.0330	446.5	.4600	472.5	.0087	498.5	.0027
395.0	.0027	421.0	.0360	447.0	.4430	473.0	.0082	499.0	.0028
395.5	.0027	421.5	.0410	447.5	.4220	473.5	.0078	499.5	.0028
396.0	.0028	422.0	.0440	448.0	.4040	474.0	.0074	500.0	.0029
396.5	.0029	422.5	.0470	448.5	.3850	474.5	.0070		

Band F4, 441 Wavenumber Channel

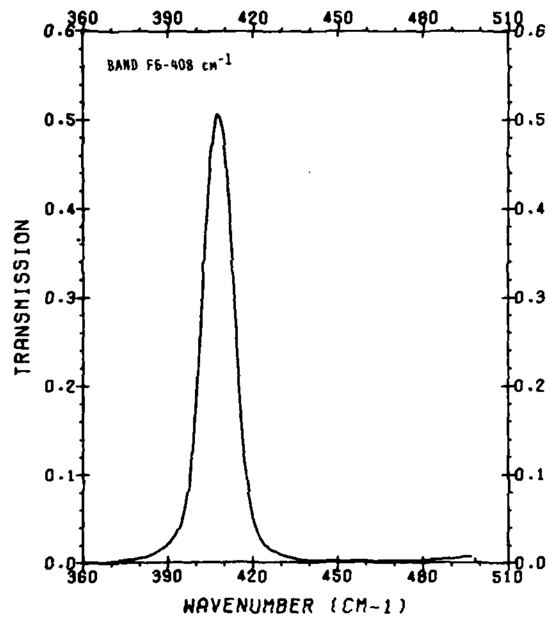
DMSP FILTER NO. 13536
535 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

FREQUENCY	FILTER TRANSMISSION
497.5	.0010
498.0	.0011
498.5	.0011
499.0	.0012
499.5	.0013
500.0	.0014
500.5	.0015
501.0	.0016
501.5	.0017
502.0	.0018
502.5	.0019
503.0	.0021
503.5	.0022
504.0	.0024
504.5	.0026
505.0	.0028
505.5	.0030
506.0	.0032
506.5	.0035
507.0	.0038
507.5	.0041
508.0	.0044
508.5	.0049
509.0	.0054
509.5	.0059
510.0	.0064
510.5	.0068
511.0	.0076
511.5	.0082
512.0	.0090
512.5	.0100
513.0	.0110
513.5	.0120
514.0	.0130
514.5	.0150
515.0	.0160
515.5	.0180
516.0	.0200
516.5	.0220
517.0	.0250
517.5	.0270
518.0	.0300
518.5	.0330
519.0	.0360
519.5	.0390
520.0	.0440
520.5	.0500
521.0	.0580

FREQUENCY	FILTER TRANSMISSION
521.5	.0670
522.0	.0800
522.5	.0930
523.0	.1070
523.5	.1220
524.0	.1390
524.5	.1700
525.0	.1990
525.5	.2340
526.0	.2700
526.5	.3240
527.0	.3730
527.5	.4240
528.0	.4710
528.5	.5100
529.0	.5490
529.5	.5760
530.0	.5900
530.5	.5930
531.0	.5900
531.5	.5830
532.0	.5710
532.5	.5620
533.0	.5420
533.5	.5310
534.0	.5210
534.5	.5110
535.0	.5050
535.5	.5050
536.0	.5070
536.5	.5120
537.0	.5160
537.5	.5180
538.0	.5210
538.5	.5220
539.0	.5170
539.5	.5080
540.0	.4900
540.5	.4620
541.0	.4310
541.5	.3990
542.0	.3560
542.5	.3190
543.0	.2720
543.5	.2370
544.0	.2020
544.5	.1690
545.0	.1420

FREQUENCY	FILTER TRANSMISSION
545.5	.1210
546.0	.1050
546.5	.0890
547.0	.0780
547.5	.0670
548.0	.0570
548.5	.0500
549.0	.0420
549.5	.0360
550.0	.0320
550.5	.0290
551.0	.0270
551.5	.0230
552.0	.0200
552.5	.0190
553.0	.0170
553.5	.0160
554.0	.0140
554.5	.0130
555.0	.0120
555.5	.0110
556.0	.0100
556.5	.0091
557.0	.0086
557.5	.0079
558.0	.0074
558.5	.0069
559.0	.0065
559.5	.0061
560.0	.0058
560.5	.0054
561.0	.0052
561.5	.0049
562.0	.0046
562.5	.0043
563.0	.0041
563.5	.0039
564.0	.0037
564.5	.0035
565.0	.0034
565.5	.0033
566.0	.0032
566.5	.0030
567.0	.0029
567.5	.0028
568.0	.0026
568.5	.0025

Band F5, 535 Wavenumber Channel

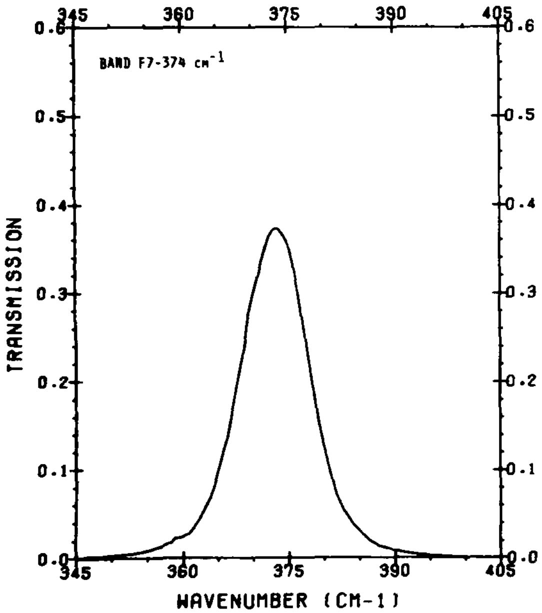


Band F6. 408 Wavenumber Channel

DMSP FILTER NO. 13536
408 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
368.0	.0010	394.0	.0410	420.0	.0450	446.0	.0017	472.0	.0013
368.5	.0011	394.5	.0470	420.5	.0400	446.5	.0017	472.5	.0014
369.0	.0011	395.0	.0530	421.0	.0370	447.0	.0017	473.0	.0014
369.5	.0012	395.5	.0600	421.5	.0340	447.5	.0016	473.5	.0015
370.0	.0013	396.0	.0700	422.0	.0300	448.0	.0016	474.0	.0015
370.5	.0014	396.5	.0770	422.5	.0270	448.5	.0016	474.5	.0016
371.0	.0015	397.0	.0880	423.0	.0250	449.0	.0015	475.0	.0016
371.5	.0016	397.5	.1020	423.5	.0220	449.5	.0014	475.5	.0017
372.0	.0017	398.0	.1230	424.0	.0200	450.0	.0014	476.0	.0017
372.5	.0018	398.5	.1380	424.5	.0190	450.5	.0013	476.5	.0017
373.0	.0019	399.0	.1600	425.0	.0180	451.0	.0012	477.0	.0018
373.5	.0020	399.5	.1850	425.5	.0160	451.5	.0012	477.5	.0018
374.0	.0021	400.0	.2090	426.0	.0150	452.0	.0011	478.0	.0018
374.5	.0023	400.5	.2330	426.5	.0140	452.5	.0011	478.5	.0018
375.0	.0024	401.0	.2660	427.0	.0130	453.0	.0010	479.0	.0019
375.5	.0026	401.5	.2950	427.5	.0130	453.5	.0010	479.5	.0019
376.0	.0027	402.0	.3250	428.0	.0120	454.0	.0010	480.0	.0019
376.5	.0029	402.5	.3550	428.5	.0110	454.5	.0010	480.5	.0020
377.0	.0031	403.0	.3830	429.0	.0100	455.0	.0011	481.0	.0021
377.5	.0033	403.5	.4080	429.5	.0095	455.5	.0011	481.5	.0022
378.0	.0035	404.0	.4320	430.0	.0089	456.0	.0011	482.0	.0023
378.5	.0038	404.5	.4520	430.5	.0083	456.5	.0011	482.5	.0025
379.0	.0041	405.0	.4690	431.0	.0078	457.0	.0011	483.0	.0026
379.5	.0044	405.5	.4860	431.5	.0073	457.5	.0011	483.5	.0028
380.0	.0047	406.0	.4950	432.0	.0068	458.0	.0011	484.0	.0029
380.5	.0051	406.5	.5040	432.5	.0064	458.5	.0011	484.5	.0030
381.0	.0055	407.0	.5060	433.0	.0060	459.0	.0011	485.0	.0031
381.5	.0059	407.5	.5040	433.5	.0056	459.5	.0011	485.5	.0032
382.0	.0064	408.0	.4990	434.0	.0052	460.0	.0011	486.0	.0032
382.5	.0069	408.5	.4920	434.5	.0049	460.5	.0011	486.5	.0033
383.0	.0075	409.0	.4820	435.0	.0045	461.0	.0012	487.0	.0035
383.5	.0080	409.5	.4680	435.5	.0043	461.5	.0012	487.5	.0036
384.0	.0087	410.0	.4500	436.0	.0040	462.0	.0012	488.0	.0037
384.5	.0093	410.5	.4270	436.5	.0038	462.5	.0012	488.5	.0038
385.0	.0100	411.0	.4070	437.0	.0036	463.0	.0012	489.0	.0039
385.5	.0110	411.5	.3800	437.5	.0034	463.5	.0012	489.5	.0040
386.0	.0120	412.0	.3510	438.0	.0032	464.0	.0012	490.0	.0041
386.5	.0130	412.5	.3200	438.5	.0030	464.5	.0012	490.5	.0043
387.0	.0140	413.0	.2950	439.0	.0029	465.0	.0012	491.0	.0046
387.5	.0150	413.5	.2700	439.5	.0027	465.5	.0012	491.5	.0048
388.0	.0160	414.0	.2300	440.0	.0025	466.0	.0012	492.0	.0050
388.5	.0170	414.5	.2050	440.5	.0024	466.5	.0012	492.5	.0053
389.0	.0180	415.0	.1760	441.0	.0023	467.0	.0013	493.0	.0055
389.5	.0200	415.5	.1570	441.5	.0022	467.5	.0013	493.5	.0058
390.0	.0210	416.0	.1380	442.0	.0020	468.0	.0013	494.0	.0060
390.5	.0230	416.5	.1180	442.5	.0020	468.5	.0013	494.5	.0062
391.0	.0250	417.0	.1050	443.0	.0019	469.0	.0013	495.0	.0063
391.5	.0270	417.5	.0930	443.5	.0019	469.5	.0013	495.5	.0065
392.0	.0290	418.0	.0800	444.0	.0019	470.0	.0013	496.0	.0066
392.5	.0320	418.5	.0700	444.5	.0019	470.5	.0013	496.5	.0068
393.0	.0350	419.0	.0610	445.0	.0018	471.0	.0013	497.0	.0071
393.5	.0370	419.5	.0520	445.5	.0018	471.5	.0013	497.5	.0073

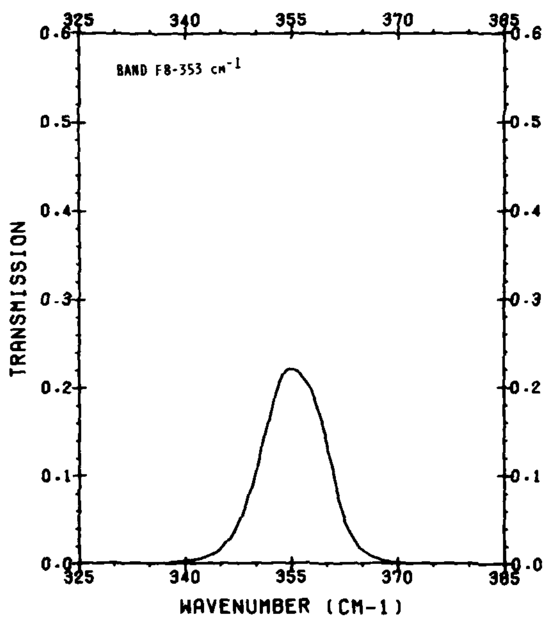
Band F6, 408 Wavenumber Channel



Band F7, 374 Wavenumber Channel

DNSP FILTER NO. 13536
374 WAVENUMBER CHANNEL
FREQUFNCY STEP= .5 WAVFNUMBFRS

FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
346.0	.0010	364.5	.0920	382.5	.0560
346.5	.0011	365.0	.1070	383.0	.0500
347.0	.0013	365.5	.1230	383.5	.0440
347.5	.0014	366.0	.1350	384.0	.0380
348.0	.0015	366.5	.1550	384.5	.0340
348.5	.0017	367.0	.1760	385.0	.0300
349.0	.0020	367.5	.1980	385.5	.0260
349.5	.0022	368.0	.2200	386.0	.0220
350.0	.0025	368.5	.2390	386.5	.0190
350.5	.0028	369.0	.2700	387.0	.0170
351.0	.0032	369.5	.2880	387.5	.0140
351.5	.0036	370.0	.3040	388.0	.0130
352.0	.0040	370.5	.3180	388.5	.0120
352.5	.0045	371.0	.3350	389.0	.0110
353.0	.0052	371.5	.3490	389.5	.0095
353.5	.0058	372.0	.3620	390.0	.0086
354.0	.0065	372.5	.3690	390.5	.0077
354.5	.0074	373.0	.3730	391.0	.0069
355.0	.0084	373.5	.3720	391.5	.0062
355.5	.0094	374.0	.3670	392.0	.0056
356.0	.0110	374.5	.3600	392.5	.0050
356.5	.0120	375.0	.3500	393.0	.0045
357.0	.0140	375.5	.3320	393.5	.0040
357.5	.0160	376.0	.3100	394.0	.0036
358.0	.0170	376.5	.2870	394.5	.0032
358.5	.0220	377.0	.2610	395.0	.0024
359.0	.0220	377.5	.2340	395.5	.0026
359.5	.0230	378.0	.2080	396.0	.0023
360.0	.0290	378.5	.1850	396.5	.0021
360.5	.0270	379.0	.1580	397.0	.0019
361.0	.0320	379.5	.1380	397.5	.0017
361.5	.0380	380.0	.1200	398.0	.0015
362.0	.0440	380.5	.1030	398.5	.0014
362.5	.0520	381.0	.0870	399.0	.0012
363.0	.0600	381.5	.0730	399.5	.0011
363.5	.0670	382.0	.0659	400.0	.0010
364.0	.0780				



Band F8, 353 Wavenumber Channel

DMSP FILTER NO. 13536
353 WAVENUMBER CHANNEL
FREQUENCY STEP= .5 WAVENUMBERS

FREQUENCY	FILTER TRANSMISSION	FREQUENCY	FILTER TRANSMISSION
337.5	.0009	354.5	.2200
338.0	.0011	355.0	.2210
338.5	.0013	355.5	.2190
339.0	.0016	356.0	.2150
339.5	.0020	356.5	.2100
340.0	.0025	357.0	.2040
340.5	.0030	357.5	.1980
341.0	.0037	358.0	.1860
341.5	.0045	358.5	.1740
342.0	.0054	359.0	.1610
342.5	.0067	359.5	.1450
343.0	.0082	360.0	.1250
343.5	.0100	360.5	.1100
344.0	.0120	361.0	.0900
344.5	.0150	361.5	.0720
345.0	.0190	362.0	.0580
345.5	.0240	362.5	.0460
346.0	.0280	363.0	.0370
346.5	.0340	363.5	.0300
347.0	.0420	364.0	.0230
347.5	.0510	364.5	.0180
348.0	.0610	365.0	.0150
348.5	.0750	365.5	.0120
349.0	.0860	366.0	.0092
349.5	.1000	366.5	.0073
350.0	.1150	367.0	.0057
350.5	.1340	367.5	.0046
351.0	.1500	368.0	.0036
351.5	.1630	368.5	.0028
352.0	.1790	369.0	.0022
352.5	.1930	369.5	.0018
353.0	.2050	370.0	.0014
353.5	.2130	370.5	.0011
354.0	.2180	371.0	.0009

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